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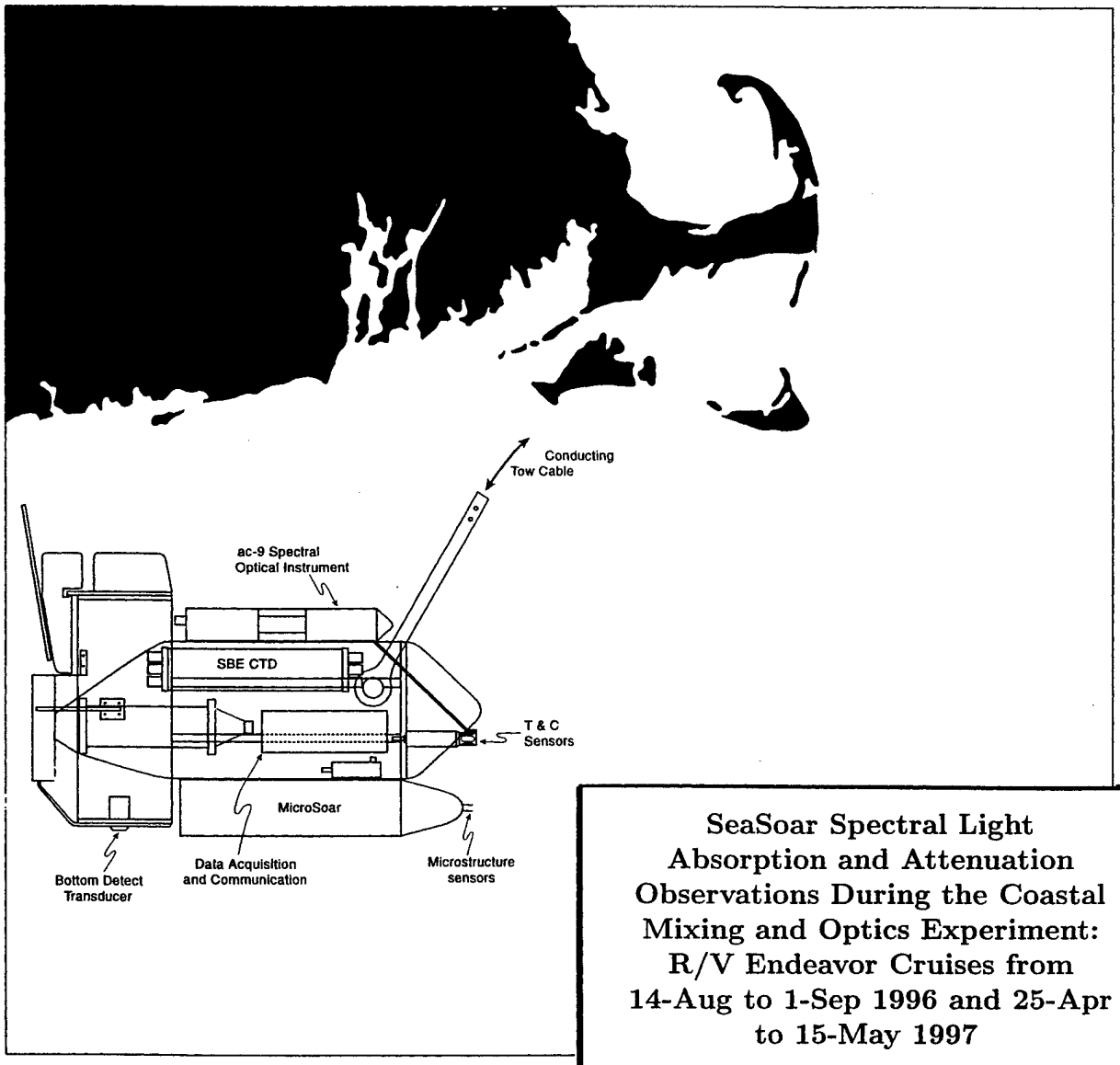


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## SeaSoar Spectral Light Absorption and Attenuation Observations During the Coastal Mixing and Optics Experiment: R/V Endeavor Cruises from 14-Aug to 1-Sep 1996 and 25-Apr to 15-May 1997

by

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# SeaSoar Spectral Light Absorption and Attenuation Observations During the Coastal Mixing and Optics Experiment: R/V Endeavor Cruises from 14-Aug to 1-Sep 1996 and 25-Apr to 15-May 1997

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*http://diana.oce.orst.edu/cmoweb/ac9/main.html*

This data report includes documentation of the Coastal Mixing and Optics (CMO) Experiment inherent optical property surveys on the continental shelf and slope in the Mid-Atlantic Bight south of Cape Cod, Massachusettes, USA. The surveys were conducted aboard the *R/V Endeavor* during two physical oceanography cruises: E9608 (14 August to 1 September 1996) and E9704 (25 April to 15 May 1997). The objective of the CMO Experiment was to rapidly survey a region in the Mid-Atlantic Bight (centered around 40.5°N, 70.5°W) to obtain three-dimensional, high-resolution measurements which would allow further elucidation of the lengthscales, distributions and relationships between hydrographic and optical properties. This report describes the installation and deployment of the optical instrumentation as well as the data acquisition, data processing and editing of the inherent optical property data. Vertical sections and maps of the inherent optical properties obtained from the surveys are also presented.

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# 1 Introduction

This report includes information on the deployment, data aquisition, data processing and recorded measurements of the inherent optical properties during two physical oceanography cruises: E9608 (14 August to 1 September 1996) and E9704 (25 April to 15 May 1997). These two physical oceanography cruises were conducted by the co-PIs Jack Barth and Mike Kosro as part of the ONR-sponsored Coastal Mixing and Optics (CMO) Accelerated Research Initiative. The objective was to rapidly survey a region around 40.5°N, 70.5°W where a set of moorings and a stationary vessel conducting profiling operations were located. The first cruise (14 August to 1 September 1996) took place during a period of strong summer stratification; the second cruise was conducted in the spring (25 April to 15 May 1997) as water over the shelf restratified after mixing by winter storms.

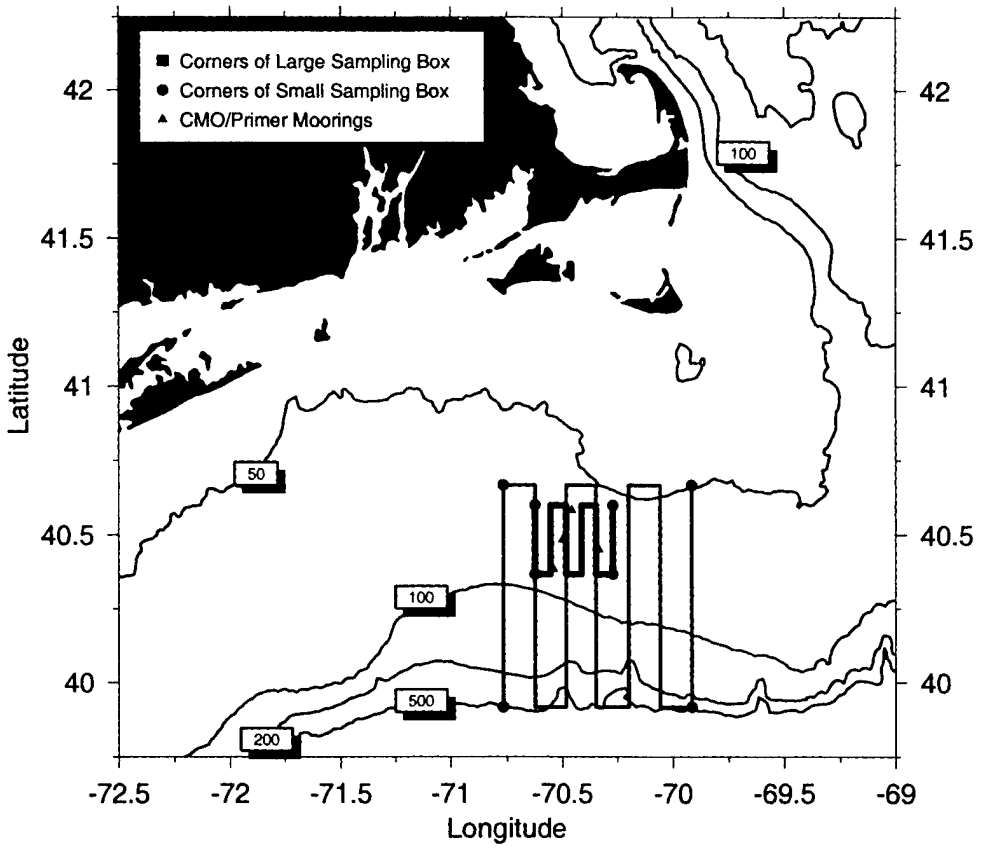



Figure 1: Map of the Coastal Mixing and Optics study region in the Middle Atlantic Bight south of Cape Cod, Massachusetts. Bottom topography in meters.

Maps of hydrographic properties, velocity (from a shipboard acoustic Doppler current profiler) and inherent optical properties were obtained over the continental shelf and slope. The water column was sampled by towing the undulating vehicle SeaSoar from the surface to within 5-7 m of the bottom. The SeaSoar tows were concentrated in three patterns: 1) a small box roughly 25 by 30 km centered on 40.5°N, 70.5°W (in 70 m of water on the mid-shelf) and with north-south lines separated by about 6 km; 2) a big box roughly 70 by 80 km which included the small box region but extended out over the continental slope and with north-south lines separated by about 12 km; and 3) a butterfly roughly 28 by 30 km centered on 40.5°N, 70.5°W. Each of these boxes was sampled repeatedly during the cruise (Figure 1). Surface temperature and salinity, and meteorological measurements were made continuously during E9608 (Figure 2) and E9704 (Figure 3).

Further details of SeaSoar operation, SeaSoar CTD processing data processing and conventional CTD data as well as cruise narratives for the two cruises can be found in O'Malley *et al.* (1998). Details of the acoustic Doppler current profiler (ADCP) operation and data processing can be found in Pierce *et al.* (1998). A summary version of this report has been previously published in *Deep-Sea Res.*, (Barth and Bogucki, 2000). All data reports are available at *http://diana.oce.orst.edu/cmoweb.*

Measurements of the inherent optical properties (IOPs) are obtained using a nine-wavelength spectral absorption and attenuation meter (WET Labs, ac-9). For readers unfamiliar with the design and engineering of an ac-9, a summary description of this field deployable spectrophotometer is as follows. The ac-9 unit is composed of two cylindrical pressure cases with dual connecting, specially designed tubes through which sampled water can flow. The shorter of the two pressure cases houses the light source, filter wheel and transmitter optics. The longer pressure case houses the receiver optics as well as the control and data aquisition electronics. Dual DC incandescent light sources from the shorter pressure case are collimated, passed through bandpass filters seated on a single rotating wheel, then transmitted through the flow tubes (25 cm pathlength). Light which has been neither absorbed (photon annihilation) nor scattered (photon redirection), through the flow tube pathlength is refocused, then sensed by detectors located in the longer pressure case. For this survey, the ac-9 was configured with the following visible spectrum wavelengths (nm): 412, 440, 510, 532, 560, 650, 676 and 715. The ac-9 power and communications are mediated by the bulkhead connector at the end of the long housing. The ac-9 operates with 10-18 volts, requires nine watts of power and sends data at about 400 bytes $s^{-1}$ over a RS-485 serial channel. A power and data communications package is necessary for the real-time transfer of data from the deployed instrument to the shipboard computers. Details of data post processing are discussed later in this report. Further recommended reading is the *ac-9 User's Guide*, WET Labs (1995).

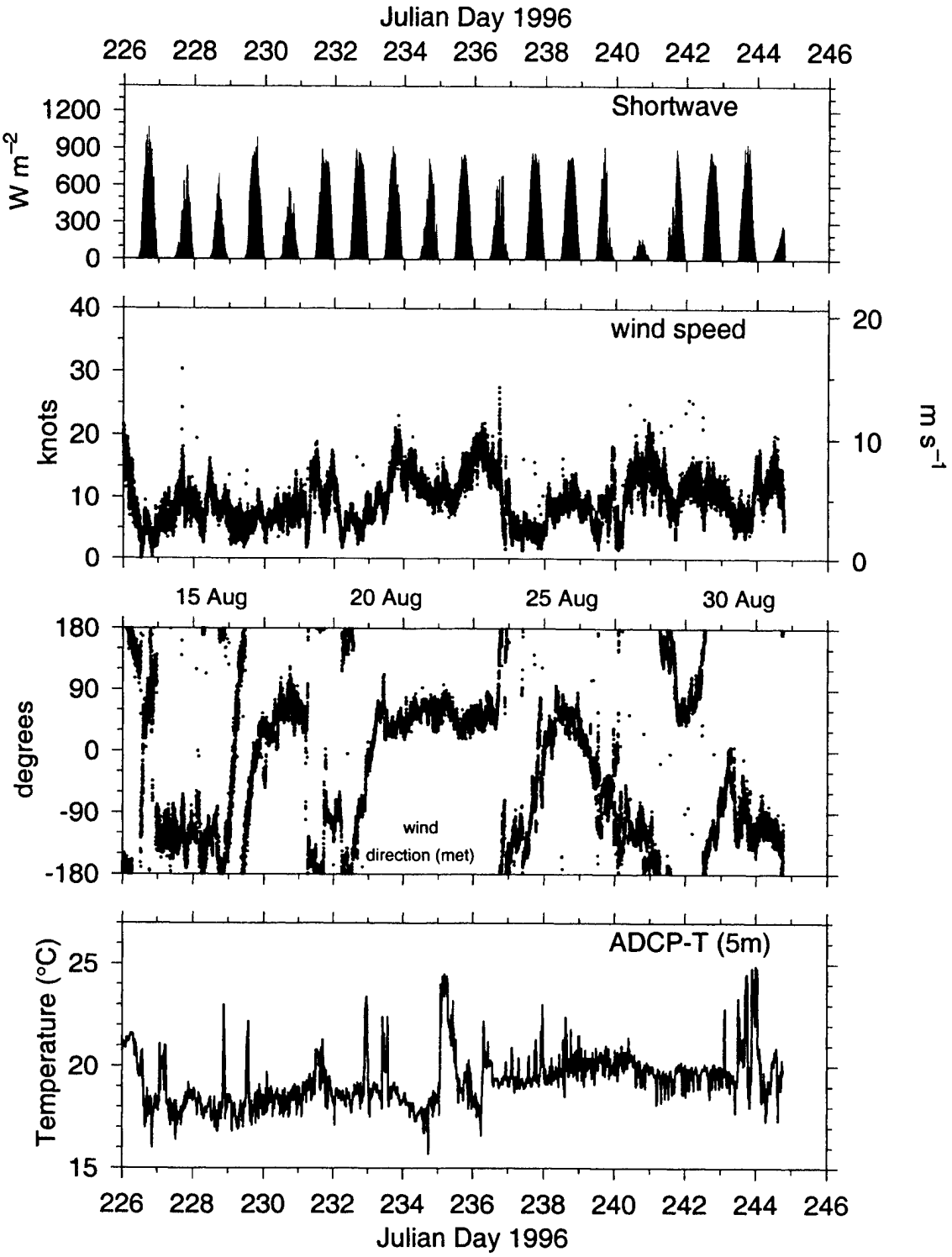



Figure 2: Irradiance, wind speed and wind direction from the R/V Endeavor's meteorological instruments, and 5-m water temperature from the ADCP transducer well during E9608.

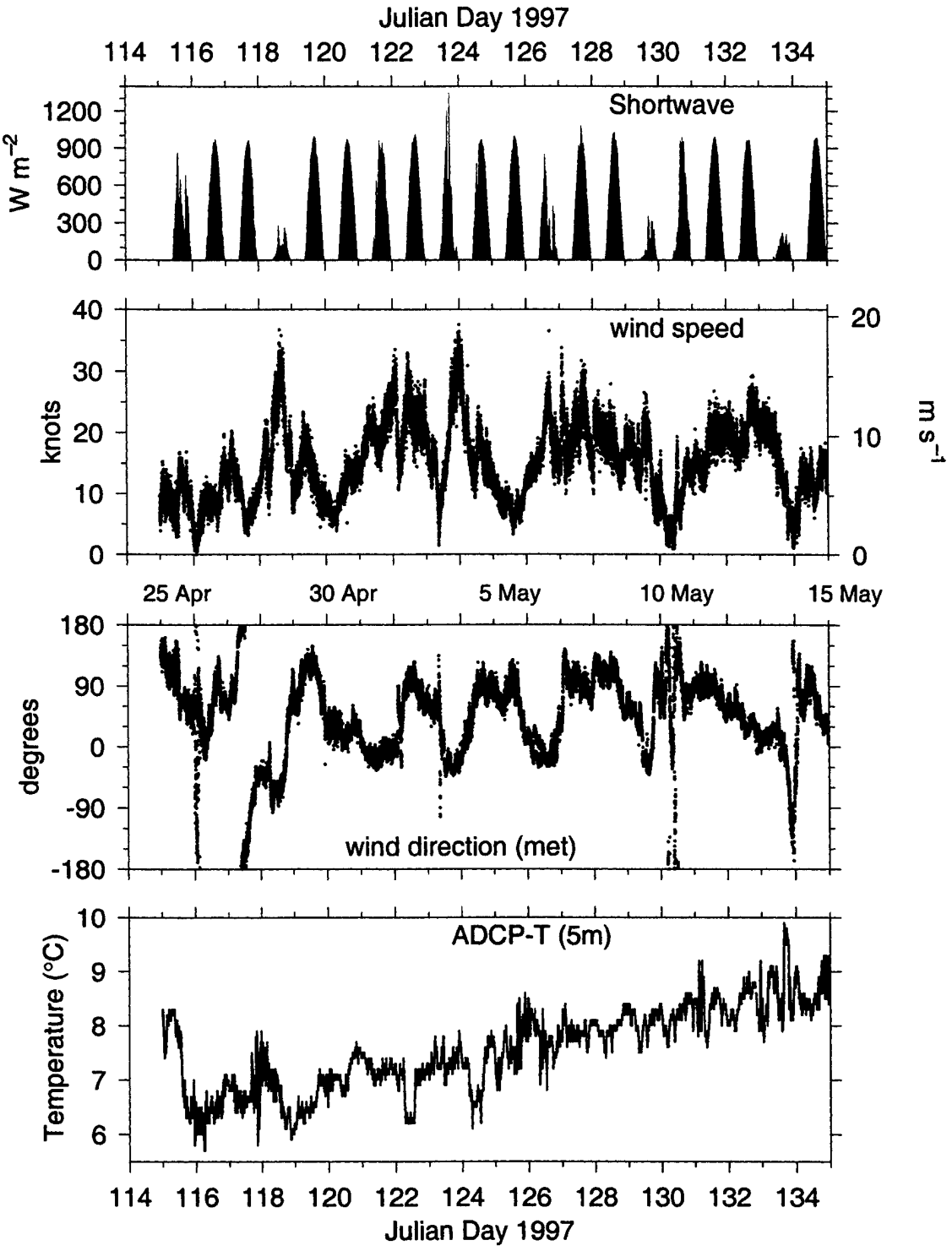



Figure 3: Irradiance, wind speed and wind direction from the R/V Endeavor's meteorological instruments, and 5-m water temperature from the ADCP transducer well during E9704.

# 2 Installation and Deployment

The SeaSoar was equipped with a Seabird 911+ conductivity-temperature-depth (CTD) instrument, a nine-wavelength light absorption and attenuation meter (WETLabs ac-9) and a new microstructure instrument, MicroSoar (*Erofeev et al.*, 1998; *Dillon et al.*, 2000), which measured conductivity and temperature using robust, fast-response probes. The Seabird (SBE) 911+ CTD, with its pressure case, was mounted inside the vehicle with the dual temperature/conductivity (T/C) sensors mounted pointing forward through SeaSoar's nose (Figure 4a). Dual SBE pumps mounted inside the vehicle ensured a steady flow past the T/C sensors. A nine-wavelength light absorption and attenuation instrument, ac-9 (WETLabs, Inc., Philomath, Oregon), was mounted on top of SeaSoar in a rigid saddle and with a streamlined nose cone to minimize drag (Figure 4b). The placement of the ac-9 on top of SeaSoar caused no adverse effects on the vehicle's performance. The rigid saddle was designed to avoid placing torque on the light paths through the ac-9's flow tubes (WETLabs, 1995; Moore and Bruce, 1996). The SBE pump for the ac-9 was mounted downstream in the flow which entered at an inlet just above the CTD T/C sensors in the nose of SeaSoar (Figure 4a). Water for the ac-9 was pumped from the inlet/outlet to ensure comparable hydrographic and optical measurements. The sampled water entered through a 1/2"-ID hose, then flowed serially through the absorption ("a") flow tube and the attenuation ("c") flow tube before passing through the pump and exiting through the outlet in a 1/2"-ID hose. The outlet was located symmetrically, with respect to the flow around SeaSoar, from the inlet to minimize any dynamic pressure gradient. The position of the outlet near the inlet does not reintroduce previously sampled water as a result of the dynamic flight of the vehicle through the water column. The SBE 5T 3000-rpm centrifugal pump is capable of an unrestricted flow rate of 150 mL $s^{-1}$. The true pumping rate during deployment was approximately 50 mL $s^{-1}$.

Power and data transfer requirements of the ac-9 were supplied by a power and data communications package, specifically, a WET Labs Modular Ocean Data and Power System (MODAPS). For the first half of the E9608 cruise, a prototype MODAPS+ unit was used, after which, a conventional MODAPS was used for the remainder of the E9608 cruise and the entire E9704 cruise. Data received from the instrument is stored on shipboard PCs or UNIX workstations. The serial data stream is also input to a real-time monitor and display software package which allows the user to monitor the instrument's performance (*Barth and Bogucki*, 2000). This is critical for the successful operation of an ac-9 aboard SeaSoar for the immediate detection of malfunction of the ac-9 plumbing system or flow tube clogging. The real-time displays of absorption and attenuation spectra, time series (single channels or algebraic combinations of channels), or color raster plots of parameters as a function of time and depth, would also allow targeted sampling concentrated on bio-optical features.

An additional optical instrument, a prototype single-channel fluorometer (FlashPak, WET-Labs, Inc.) flown at the request of CMO investigator Dr. Paula Coble (University of South Florida), was mounted alongside the ac-9 on top of SeaSoar. The FlashPak was placed downstream of the ac-9 in the pumped optics water supply, and was powered by and returned data via the SBE CTD. Results from Dr. Coble's fluorometer are not reported here.

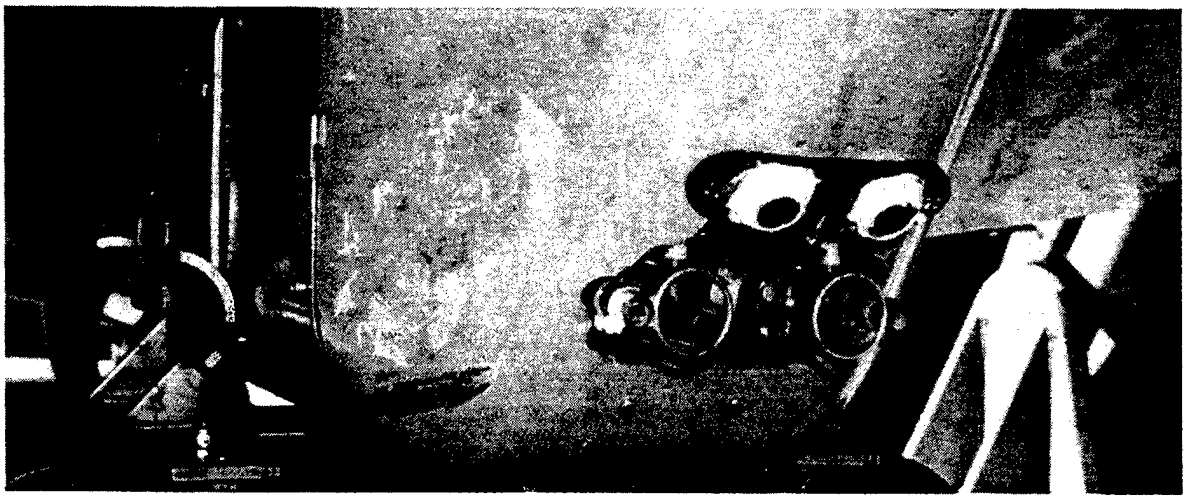
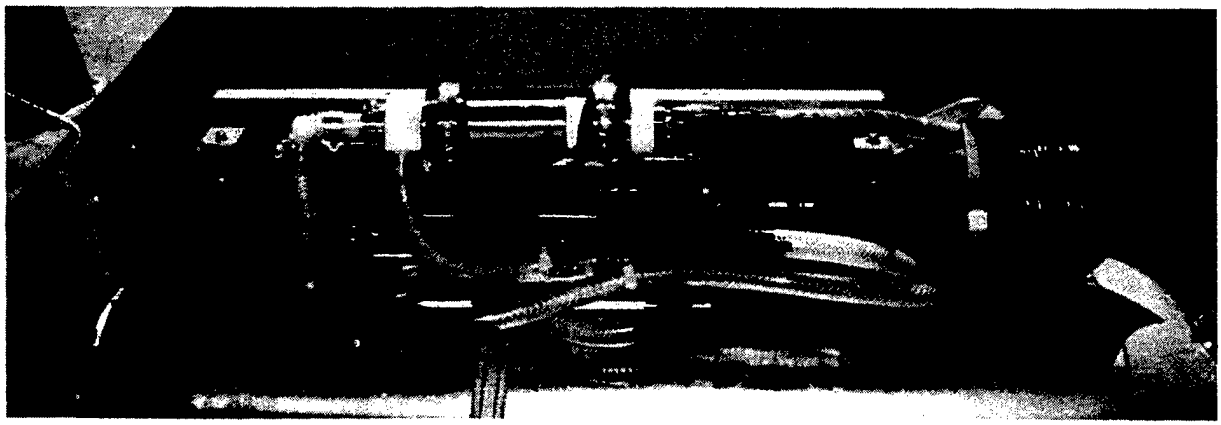


Figure 4: Inlet and outlet for the ac-9 water supply located in SeaSoar's nose adjacent to the dual Sea-Bird temperature-conductivity sensors (above). Closeup of the spectral absorption and attenuation meter (WET Labs ac-9) mounted on top of SeaSoar showing pump and hose configuration (below).



An important consideration for processing and analyzing data from SeaSoar is its flight pattern through the water column. The vehicle samples from the surface to within five to ten meters of the bottom. The ship's echosounder supplied the SeaSoar control software with water depth in order to avoid bottom collisions while the vehicle was towed at six to eight knots (3.1 to 4.1 m $s^{-1}$) behind a research vessel. During the CMO experiment conducted over the continental shelf, the time to complete an ascending and descending cycle varied between 1.5 and 4.0 minutes for shallow (55 m) and deep (105 m) profiles, respectively. The vehicle's vertical speed varied with depth and differed between the ascending and descending profiles. Vertical speeds ranged from 0 to 3 m $s^{-1}$, with an average value of 1 m $s^{-1}$ (*Barth and Bogucki*, 2000). The SeaSoar's typical vertical speed is in excess of the typical descent

and ascent rates used while profiling from a stationary research vessel. The variable flow past the vehicle has the potential to influence the pumped flow rates through dynamic pressure gradients, but, as demonstrated by Barth *et al.* (1996) this effect is small. The vehicle's vertical velocity influences the ac-9's vertical resolution given its 6-Hz sampling rate and is critical for calculating depth offsets from time lags induced by water samples passing through the plumbing and optical flow tubes (see following section).

Throughout the 11 days of towing SeaSoar during the 1996 CMO Experiment, the vehicle was recovered only a few times to correct problems with the optical instrumentation. Partial clouding of the optical paths in one or the other flow tube occurred several times during the E9608 cruise due to inefficient clearance of gelatinous plankton from the flow tubes. Data from these periods were recoverable using a technique described in the next section. During the E9704 cruise, on 30 April, an electrical short caused the loss of a MODAPS communications channel. This required an alteration in the power and data communications system configuration for the remainder of the E9704 cruise. The SBE data telemetry was run in parallel with the RS-485 MODAPS communications. This configuration permitted the potential for crosstalk between the CTD (run by SBE data telemetry) and the ac-9 and MicroSoar (both run by the MODAPS data telemetry). The use of the SBE data telemetry with the RS-485 MODAPS communications resulted in a reduction of acquired ac-9 data which has made the time lag correction and merging of the CTD files with IOP files, at times, unfeasible.

# 3 Data Processing and Editing

The attainment of accurate IOP measurements from a towed platform requires a multi-step post-processing procedure: 1) factory calibration; 2) merging of ac-9 data with navigational and hydrographic data; 3) time lag correction; 4) temperature and salinity correction; 5) post-calibration correction; and 6) scattering correction. Then, the processed data is edited to eliminate data spikes, incomplete spectra, values associated with excessive variances, values associated with GPS errors and, if possible, to adjust values to eliminate offsets due to a clouding substance.

The filenaming convention for the summer and spring cruise data files is as follows: eYYP#L#(##); where e = *R/V Endeavor*, YY = year (e.g. 96, 97), P# = pattern number (e.g. smallbox (s), bigbox (b), butterfly (f)) and L#(##) = line number (e.g. 5, ns). So that the filename "e97s5l6" reads, cruise E9704, Smallbox 5, Line 6 or "e96f2lns" reads, cruise E9608, Butterfly 2, Line north to south. An extension is added to indicate different types of files. The possible extensions are: .dat, .acvar, .ac.cut and .ac.junk. The first extension, .dat, indicates an edited file which has undergone data quality checks and is considered the final product. The second extension, .acvar, indicates a data file that contains the calculated variance in the processed, unedited data. The third extension, .ac.cut, indicates a data file that contains processed data with some editing, but prior to a clog adjustment (see Table 1). The fourth extension, .ac.junk, indicates a file that contains data which have been removed from the processed, unedited data file. The columns in files with extensions, .dat, are ordered

1) Julian Date
2) latitude
3) longitude
4) pressure
5) temperature
6) salinity
7) sigma-t
8-16) absorption (412 440 488 510 532 560 650 676 715)
17-25) attenuation (412 440 488 510 532 560 650 676 715)
26) flags
27) bottom topography .

## 3.1 Factory Calibration

A factory calibration of ac-9 (S/N 152) was performed at WET Labs prior to the E9608 cruise, on 8 May 1996. Subsequent factory calibrations were again performed before and after the E9704 cruise on 23 October 1996 and 26 August 1997, respectively. The factory calibration is necessary for the removal of pure water offsets from the acquired, raw IOP measurements. The ac-9, like any spectrophotometer, requires a reference substance with which to compare measured values. In this case, the ac-9 is factory calibrated to measure the absorption and attenuation coefficients, respectively symbolized as $a$ and $c$, at nine wavelengths, relative to pure water at 25°C. This allows the detection of optical signals of

suspended dissolved and particulate materials removed from pure water. During the factory pure water calibration, a calibration file containing the pure water value readings is created. This calibration file is utilized by the factory-provided ac-9 software (1995) to correct the clean water offsets in the raw measurements. Further details can be found in the WET Labs *ac-9 User's Guide.*

## 3.2 Merging of ac-9 data with navigational and hydrographic data

The 6-Hz ac-9 data stream, averaged to 1-second values, is merged with the ship's GPS navigational record as well as with the SeaSoar hydrographic data stream. The ac-9 data stream, though recorded concurrently in real-time with the GPS and hydrographic data, must be processed to account for delays in the transmission of data packets, flow delays due to residence time in the plumbing and random errors due to sometimes poor transmission. The main purpose of the data processing is to remove these effects. First, the ac-9 data stream is synchronized with the rest of the SeaSoar data by matching the two independent pressure traces. This is accomplished given the depth and internal time of the ac-9 as well as the depth and real world time from the CTD and GPS, respectively. Superimposing the two pressure traces then provides a time and location stamp for the ac-9 data stream. This process has led to the discovery that the ac-9 acquisition system clock drifts on average 1 s over 1000 s and that the drift varies considerably with time (*Barth and Bogucki*, 2000).

## 3.3 Time lag correction

The rapid movement of SeaSoar through the water column (3.1-4.1 m $s^{-1}$ in the horizontal, 0-3 m $s^{-1}$ in the vertical) contrasts with the slower (0.5 m $s^{-1}$) conventional method of vertical profiling. The dynamic movement of the SeaSoar and the plumbing for the ac-9 introduces a temporal lag in the data streams between the recorded pressure and IOP of a particular sampled volume. This results in a pressure offset between the IOP measurements from the SeaSoar's descent versus measurements from the SeaSoar's ascent, as well as the true depth. These plumbing related, space variable, time variable and other unknown delays introduced during the SeaSoar acquistion go far beyond the constant and known delays associated with the vertical profiling mode of ac-9 data acquisition. To correct the temporal offsets in the data streams, an optimal time lag is determined by varying the applied lag to minimize the difference between the descending and ascending traces. This technique relies on the existence of vertical variations in optical properties over the water column, a common situation in the coastal ocean, where subsurface optical features exist (e.g. phytoplankton layers, resuspended bottom sediments; see Figure 5).

Further, it is assumed that optical features are horizontally uniform over the distance of the SeaSoar's ascent and descent. The assumption is justified given that strong summer stratification produces temporally consistent phytoplankton and sediment vertical distributions (Houghton and Marra, 1983; Zaneveld *et al.*, 1997; Roesler *et al.*, 1997). During the CMO experiment, conducted over the continental shelf, this distance at the top and bottom of the profile varied between 300 and 800 m for shallow (55 m) and deep (105 m) profiles,

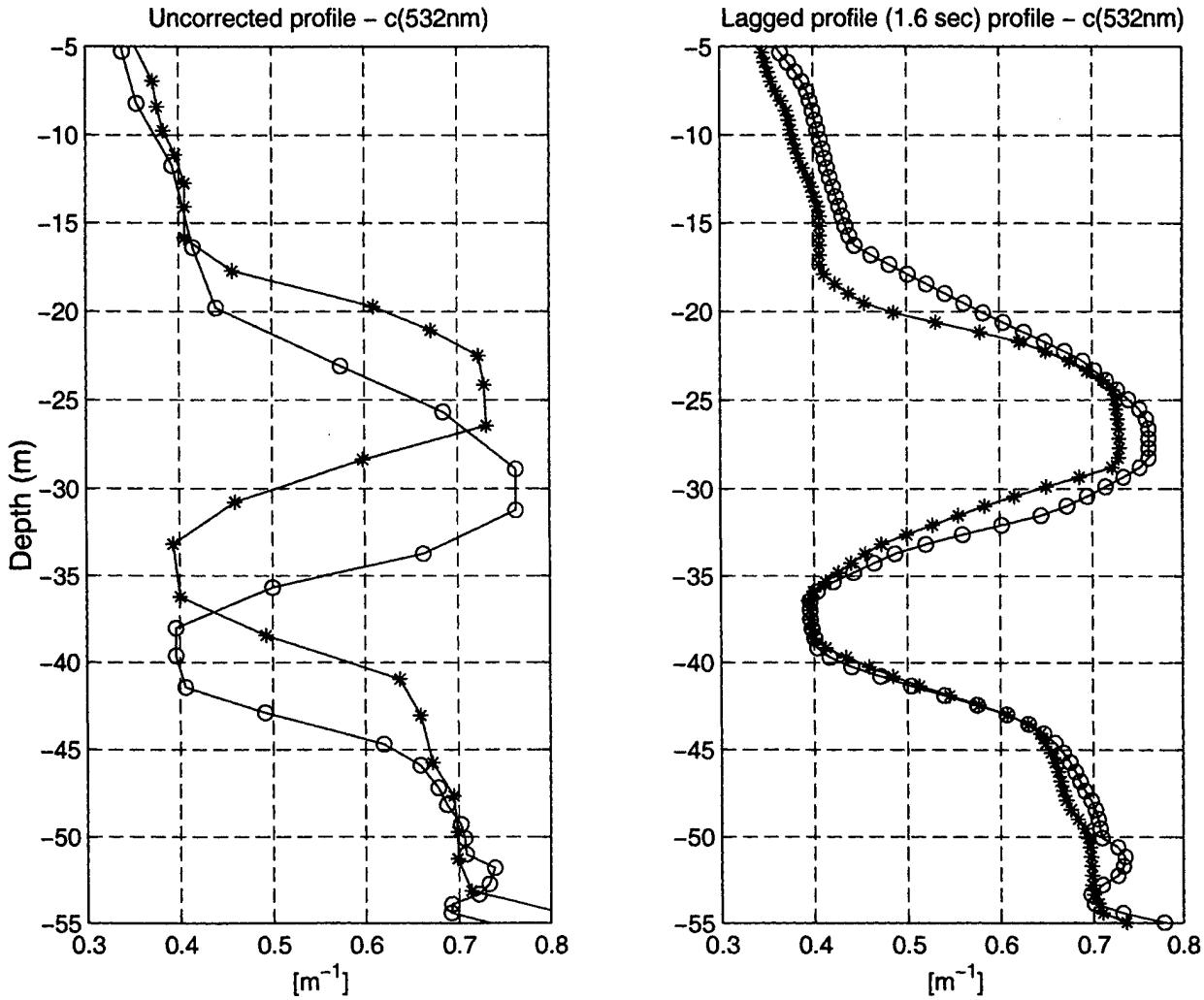



Figure 5: The $c(532)$ as a function of depth from adjacent ascending (asterisks) and descending (circles) profiles for (a) uncorrected 1-Hz data and (b) lag corrected linearly interpolated data.

respectively. Given the sawtooth shape of the SeaSoar flight path, at other depths the horizontal separation is reduced (e.g. by a factor of two at mid-depth so that measurments are separated by 150-400 m depending on the profiling depth).

To find the optimal time lag, the 1-s ac-9 measurements are first linearly interpolated to a finer spatial grid with 200 points in the vertical so a typical profile has a grid spacing of 100m/200 = 0.5 m. To translate between time lags and depth offsets, the vertical velocity, $w$, of the vehicle is computed from time differencing the CTD pressure record then filtering with a five-point running mean. For a vertical velocity of 1 m s$^{-1}$ the five point filter is about 2 s wide. Next, the time lag in the relation $z_{true} = z_{measured} - w*\text{lag}$ is varied to

minimize (in the least squares sense) the difference between the measured and optical signal on the ascending and descending traces. The optimum lag is calculated for each channel, since all 18 channels are not measured simultaneously. By example, the method applied to a 2600 s transect determined 26 lag values for each channel. The average delay over the nine absorption and nine attenuation channels as a function of ascending/descending pair number is shown in Figure 6. The mean delay over all 26 pairs for $c$ is approximately 1.35 s and -0.15 s for $a$. The negative value exists due to the ac-9 acquisition software delay, because pressure is recorded at the end of each data packet, and the "physical" delay due to a finite rate of fluid flow through the ac-9's plumbing system. The difference between the observed $a$ and $c$ delays gives a total time delay of 1.5 s. Given the length and inner diameter of the tubing, we estimate that the fluid flow speed through the ac-9's plumbing was fairly constant at approximately 50 mL $s^{-1}$. This flow rate agrees with the reported flow rate (46 mL $s^{-1}$) for a SBE 5T operating at 3000 rpm for flow through a SBE conductivity cell. The variance of the difference between the $a$ and $c$ lags (open circles in Fig. 6) is smaller than the variance for either the $a$ or $c$ lags alone, which indicates the analysis yields a good estimate of the physical delay.

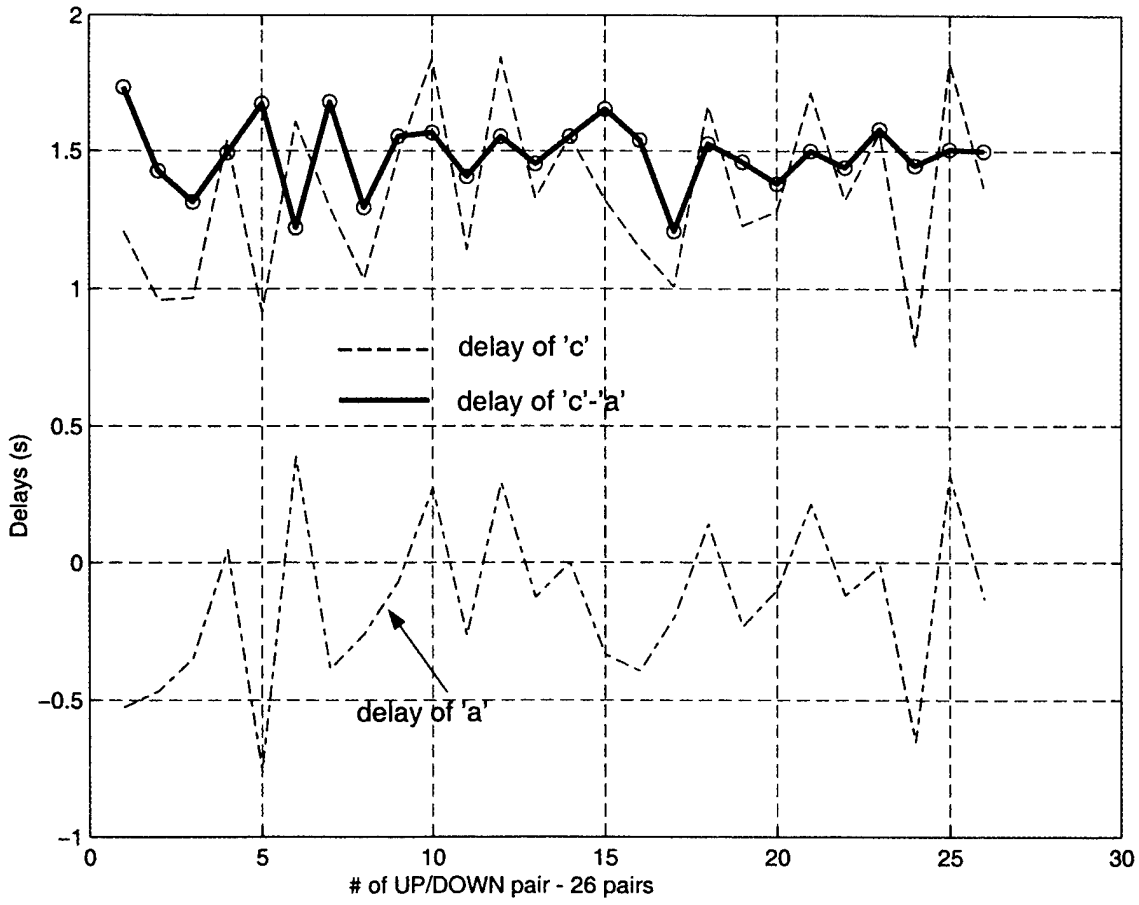



Figure 6: Time delays from lagged correlation of adjacent ascending and descending optical profiles as funciton of ascending-descending profile pairs along the SeaSoar track.

For each $a$ and $c$ channel, the optimum time lag is then multiplied by the depth-dependent veritical velocity to obtain the true depth of the optical measurements. An example of a vertical profile of $c(532\text{ nm})$ before and after removing the delay is shown in Figure 5. To find the relative "error" of the ac-9 measurements the differences between the ascending and descending absorption measurements at 532 nm normalized by the descending values as a function of depth for the entire 2600-s transect are plotted (Figure 7a). These differences could be due to both the processing technique, e.g. inability to get a good least-squares fit between ascending and descending profiles, and natural horizontal variability between profiles. The differences in vertical speed of the SeaSoar vehicle between the ascending and descending profiles are also plotted (Fig. 7b). The relative "error" is less than 10% for all $a$ and $c$ channels and there is no visible dependence of the "error" on vertical speed, lending confidence to the processing algorithm. The lag-corrected $a$ and $c$ profiles at the nine wavelengths serve as input to the next stage of processing.

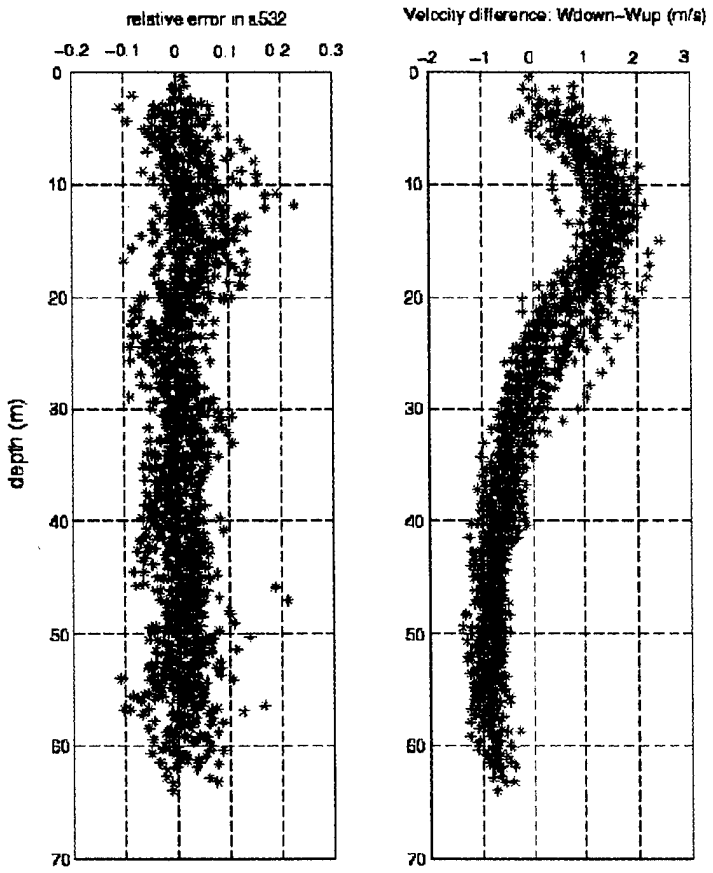



Figure 7: Relative "error" in absorption at 532 nm $((a_{ascend} - a_{descend})/a_{descend})$ and vertical velocity difference as a function of depth.

## 3.4 Temperature and Salinity Correction

The absorption spectrum of water is temperature and salinity dependent (Pegau *et al.*, 1997). The effect of temperature on the pure water absorption spectrum is much greater than that of salinity. The contrast between the 25°C pure water reference and the *in situ* instrument and water sample temperatures, which can be 10°C or less, causes a notable absorption decrease in the far red channel, 715 nm. For this region, the salinity dependence of the pure water absorption spectrum are small enough to apply a constant salinity correction (Moore and Bruce, 1996). The ac-9 does not measure the temperature of the ambient water, therefore lag-corrected temperatures measured by the CTD were applied to perform the temperature correction.

Temperature and salinity corrected absorption as a function of wavelength, $a_{TS}(\lambda)$, is calculated as

$$a_{TS}(\lambda) = a_m(\lambda) - [R1*(\mathrm{T}_m\text{-}\mathrm{T}_{ref}) + R2_a*(\mathrm{S}_{const})]$$

Temperature and salinity corrected attenuation as a function of wavelength, $c_{TS}(\lambda)$, which is also the "true" attenuation coefficient, is calculated as

$$c_{TS}(\lambda) = c_m(\lambda) - [R1*(\mathrm{T}_m\text{-}\mathrm{T}_{ref}) + R2_c*(\mathrm{S}_{const})]$$

Here, the subscript, $m$, indicates the *in situ* measured parameter. The subscript, $ref$, indicates the reference sample and the $R$ coefficients are empirically derived correction coefficients (Pegau *et al.*, 1997; Moore and Bruce, 1996). Table 1 lists the correction coefficients used to process the CMO optical data.

Table 1. Temperature and Salinity Correction Coefficients

| $\lambda[nm]$ | $R1$ $[\mathrm{m}^{-1}\ (^{\circ}\mathrm{C})^{-1}]$ | $R2_a$ $[\mathrm{m}^{-1}\ \mathrm{psu}^{-1}]$ | $R2_c$ $[\mathrm{m}^{-1}\ \mathrm{psu}^{-1}]$ |
|---|---|---|---|
| 412 | 0.0000 | 0.00018 | 0.00007 |
| 440 | 0.0000 | 0.00008 | -0.00007 |
| 488 | 0.0000 | 0.00008 | -0.00007 |
| 510 | 0.0002 | 0.00009 | -0.00007 |
| 532 | 0.0001 | 0.00004 | -0.00008 |
| 560 | 0.0001 | 0.00008 | -0.00008 |
| 650 | 0.0001 | 0.00011 | -0.00005 |
| 676 | 0.0001 | 0.00008 | -0.00007 |
| 715 | 0.0029 | -0.00008 | -0.00032 |

## 3.5 Post Calibration Correction

During a cruise, frequent clean water calibrations and cleanings of the ac-9 are recommended for the most accurate IOP measurements. The use of a calibration reference record is valid so

long as the instrument configuration, temperature, optics, etc. as well as the ambient temperature, temperature of the sampled volume and ambient air quality are identical. Therefore, updates of the reference record is recommended after physically moving the instrument. Frequent clean water calibrations and cleaning of the ac-9 were impractical during the cruise given the sampling method of multi-day towing of the SeaSoar. The ac-9 optics were thoroughly cleaned between each SeaSoar tow of which there were 15(10) during E9608(E9704). To mitigate any errors in the IOP measurements due to use of an outdated reference record, processed and edited SeaSoar IOP data were compared to spatially (horizontal and vertical) and temporally similar stationary, vertical IOP profiles collected by the Oregon State University optical oceanography group's vertical profiler, Slow-Drop, aboard *R/V Seward Johnson* (August-September 1996) and aboard the *R/V Knorr* (April 1997). Table 3 lists data files used to determine post-calibration offsets. The E9704 cruise post-calibration calculation was limited by the availability of comparable Slow-Drop data (existing Slow-Drop IOP data for the majority of the cruise are filtered measurements, therefore incompatible with the SeaSoar unfiltered ac-9 data).

Table 3. Coincident SeaSoar and Slow-Drop Measurements

| *R/V Endeavor* Filename | *R/V Johnson* Filename | Start Time | Stop Time | Latitude,°N | Longitude,°W | Depth range (meter |
|---|---|---|---|---|---|---|
| e96b11C | | 17-Aug-96 19:24 | 17-Aug-96 20:11 | 40.17 to 40.64 | 70.48 | 40-60 |
| | c9681807 | 18-Aug-96 07:00 | | 40.17 | 70.50 | 40-60 |
| | c9681808 | 18-Aug-96 08:46 | | 39.99 | 70.50 | 40-60 |
| e96f21we | | 27-Aug-96 11:12 | 27-Aug-96 14:15 | 40.41 to 40.52 | 70.28 to 70.65 | 20-30 |
| | c9682701 | 27-Aug-96 12:18 | | 40.50 | 70.49 | 20-30 |
| | c9682702 | 27-Aug-96 12:31 | | 40.50 | 70.49 | 20-30 |
| | c9682703 | 27-Aug-96 12:41 | | 40.50 | 70.49 | 20-30 |
| | c9682704 | 27-Aug-96 12:54 | | 40.50 | 70.49 | 20-30 |
| | c9682705 | 27-Aug-96 13:05 | | 40.50 | 70.49 | 20-30 |
| | c9682706 | 27-Aug-96 13:15 | | 40.50 | 70.49 | 20-30 |
| e96f2ns | | 27-Aug-96 17:31 | 27-Aug-96 20:00 | 40.37 to 40.63 | 70.43 to 70.53 | 1-20 |
| | c9682712 | 27-Aug-96 17:34 | | 40.49 | 70.49 | 1-20 |
| | c9682713 | 27-Aug-96 17:45 | | 40.50 | 70.49 | 1-20 |
| | c9682714 | 27-Aug-96 18:57 | | 40.50 | 70.47 | 1-20 |
| | c9682715 | 27-Aug-96 19:07 | | 40.50 | 70.47 | 1-20 |
| | c9682716 | 27-Aug-96 19:20 | | 40.50 | 70.47 | 1-20 |
| | c9682717 | 27-Aug-96 19:29 | | 40.50 | 70.47 | 1-20 |
| | c9682718 | 27-Aug-96 19:38 | | 40.50 | 70.47 | 1-20 |
| | c9682719 | 27-Aug-96 19:48 | | 40.50 | 70.47 | 1-20 |
| e96b31F | | 01-Sep-96 00:21 | 01-Sep-96 04:46 | 39.75 to 40.33 | 70.06 | 60-10( |
| | c9690508 | 05-Sep-96 18:14 | | 40.00 | 70.50 | 60-10( |
| | c9690509 | 05-Sep-96 12:57 | | 40.00 | 70.50 | 60-10( |
| | c9690601 | 06-Sep-96 13:07 | | 39.85 | 70.50 | 60-10( |
| | c9690602 | 06-Sep-96 13:18 | | 39.85 | 70.50 | 60-10( |
| | c9690603 | 06-Sep-96 13:18 | | 39.85 | 70.50 | 60-10( |
| *R/V Endeavor* Filename | *R/V Knorr* Filename | Start Time | Stop Time | Latitude,°N | Longitude,°W | Depth range (meter |
| e97s3l3 | | 29-Apr-97 11:21 | 29-Apr-97 13:27 | 40.3 to 40.6 | 70.5 | 15-40 |
| | C9742901 | 29-Apr-97 12:52 | | 40.5 | 70.49 | 15-40 |
| | C9742902 | 29-Apr-97 13:02 | | 40.5 | 70.49 | 15-40 |
| | C9742903 | 29-Apr-97 13:10 | | 40.5 | 70.49 | 15-40 |
| | C9742904 | 29-Apr-97 13:17 | | 40.5 | 70.49 | 15-40 |
| | C9742905 | 29-Apr-97 13:28 | | 40.5 | 70.49 | 15-40 |
| | C9742906 | 29-Apr-97 13:34 | | 40.5 | 70.49 | 15-40 |

To obtain the post-calibration offsets, SeaSoar and Slow Drop profiles were first averaged into 1 meter depth bins. Less than five SeaSoar profiles were used to construct the average SeaSoar vertical profile. The Slow-Drop files listed in Table 3 indicate the data used to obtain an averaged Slow-Drop profile. The temporal and spatial window of SeaSoar optical data used for the post-calibration was necessarily restrictive to achieve SeaSoar profiles comparable to the stationary, vertical profiles. SeaSoar data extracted to calculate the average SeaSoar profiles were at the nearest possible location (1 km or less) and within an hour of the stationary, vertical profiles. In two cases, the comparison of "clear" deep (> 100 m) water measurements were also used to determine the offset in SeaSoar data from Slow-Drop's data. The deep water profiles were not subjected to a restrictive time window. Since differences between the above specified SeaSoar and Slow-Drop profiles were still observed due to spatial heterogeneity, the post-calibration offsets were calculated using only portions

of the vertical profiles where the average of the differences ($10 < N < 40$) between SeaSoar and Slow-Drop profiles exhibited low standard deviations. The depth intervals chosen for inclusion in the calculation of the post-calibration offset are documented in the last column of Table 3.

A final, wavelength-dependent offset is obtained from the comparison of the temperature and salinity corrected Slow-Drop and SeaSoar IOP measurements (Table 4). The results of the comparison between the Slow Drop and SeaSoar profiles show that the offsets in $a(\lambda)$ generally decrease as a function of wavelength during both cruises (see Table 4). Offsets in $a$ at each wavelength exhibited a fairly consistent range of deviation over time (Figure 9). The E9608 data offsets in $c(\lambda)$ are generally spectrally flat with a spectrally constant deviation (see Table 4). The calculated offsets in $c$ (Figure 8) contrasts the offsets in $a$ (Figure 9) with a much larger deviation over time.

Table 4. Mean post-calibration offsets for T,S corrected $a$ and $c$

| wavelength | E9608 offset | E9608 std dev | E9704 offset | E9704 std dev |
|---|---|---|---|---|
| $a(412)$ | 0.0703 | 0.0996 | 0.1019 | 0.0014 |
| $a(440)$ | 0.0513 | 0.1018 | 0.0788 | 0.0014 |
| $a(488)$ | 0.0460 | 0.1022 | 0.0580 | 0.0012 |
| $a(510)$ | 0.0451 | 0.1020 | 0.0648 | 0.0009 |
| $a(532)$ | 0.0458 | 0.1018 | 0.0496 | 0.0008 |
| $a(560)$ | 0.0402 | 0.1023 | 0.0494 | 0.0009 |
| $a(650)$ | 0.0358 | 0.1026 | 0.0384 | 0.0006 |
| $a(676)$ | 0.0403 | 0.1025 | 0.0674 | 0.0012 |
| $a(715)$ | 0.0227 | 0.1040 | 0.0286 | 0.0005 |
| $c(412)$ | 0.0182 | 0.1086 | 0.0203 | 0.0065 |
| $c(440)$ | 0.0210 | 0.1082 | 0.0176 | 0.0081 |
| $c(488)$ | 0.0224 | 0.1084 | 0.0223 | 0.0087 |
| $c(510)$ | 0.0292 | 0.1077 | 0.0241 | 0.0088 |
| $c(532)$ | 0.0372 | 0.1070 | 0.0060 | 0.0081 |
| $c(560)$ | 0.0258 | 0.1080 | 0.0135 | 0.0080 |
| $c(650)$ | 0.0275 | 0.1072 | 0.0285 | 0.0111 |
| $c(676)$ | 0.0305 | 0.1070 | 0.0233 | 0.0109 |
| $c(715)$ | 0.0005 | 0.1123 | 0.0078 | 0.0116 |

The ensemble mean of the post-calibration offsets shown in Figures 8 and 9 were used to calculate mean, wavelength-dependent, post-calibration offsets shown in Table 4. The ensemble mean offsets are then subtracted from the temperature and salinity corrected E9608 and E9704 spectra. The comparisons of post-calibrated SeaSoar and Slow-Drop attenuation (Figure 10a and 11a) and absorption (Figure 10b and 11b) spectra show that the subtraction of a mean post-calibration offset from temperature and salinity corrected data retrieves the Slow-Drop temperature and salinity corrected spectra. Correlation coefficients calculated for comparable E9608 and E9704 post-calibrated SeaSoar and temperature and salinity corrected Slow-Drop data are $r \approx 0.8$ and $r \approx 0.95$ (Figures 12-15).

The validity of the application of the E9608 and E9704 post-calibration corrections were assessed using selected data subsamples that temporally spanned the length of the cruise periods. After examining the sub-sampled data for effects of the post-calibration on the magnitude and shape of the $a$ and $c$ spectra, it was determined that the post-calibration

offsets for the E9608 optical data were satisfactory, but the post-calibration offsets for the E9704 optical data led to poor results. Therefore, the post-calibration was performed only on the E9608 data set. The E9704 post-calibration offsets are presented here to allow individual investigators to gauge the magnitude of the errors in the E9704 optical data that are due to poor calibration and/or instrument noise or drift. The scattering correction follows to complete the ac-9 IOP data processing.

## 3.6 Scattering Correction

The ac-9's reflective flow tube, used to obtain absorption measurements, imperfectly captures all the scattered light travelling towards the detector. Thus, the absorption coefficients, as measured by the detector, is an overestimate of the true absorption. It is, therefore,

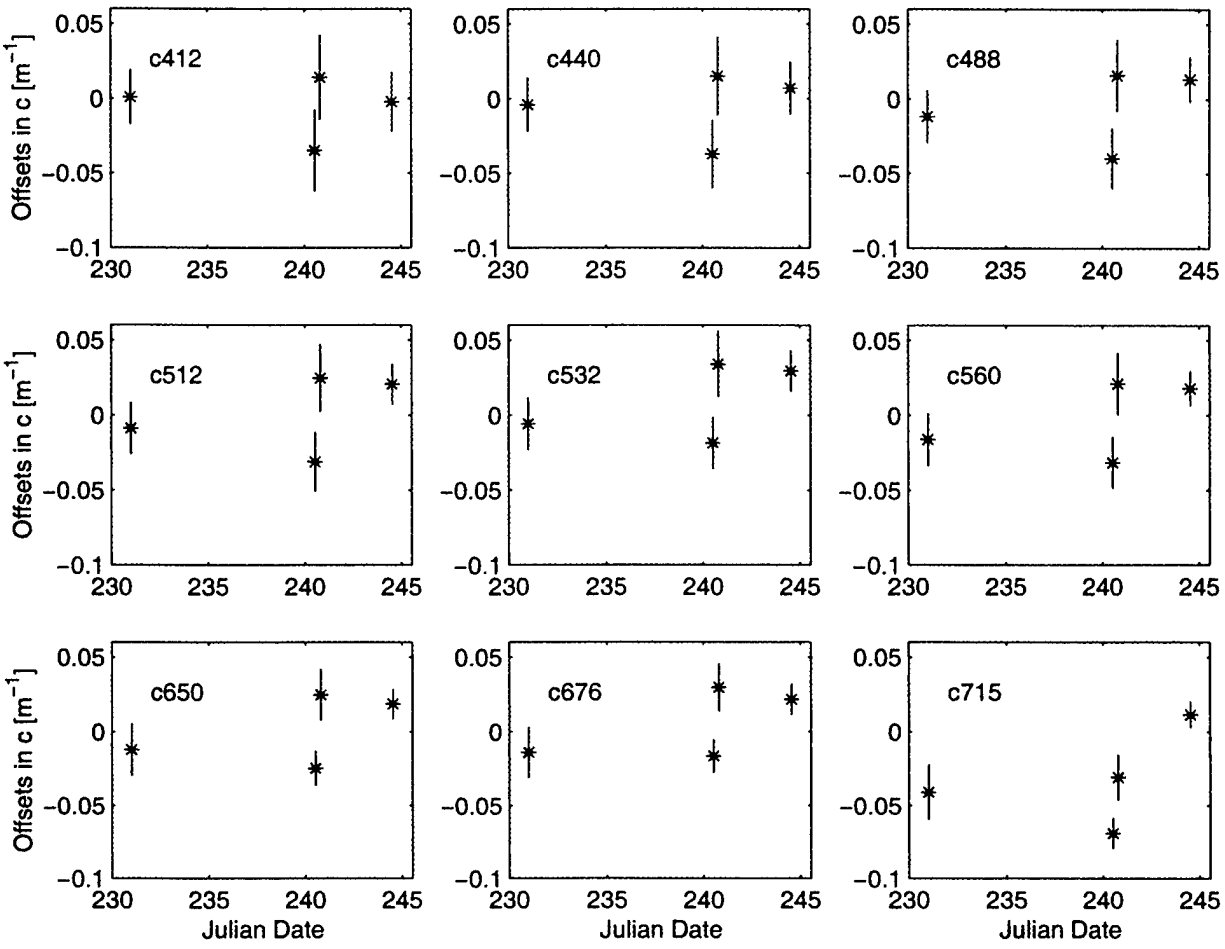



Figure 8: Post-calibration offsets in attenuation spectra as a function of time. Profiles taken from spatially and temporally comparable SeaSoar (<5 profiles) and Slow-Drop (<8 profiles) measurements are each averaged into 1-m bins then offsets are calculated from the differences in the smoothed profiles. Offsets are calculated from regions of the vertical profile exhibiting the smallest standard deviation.

necessary to apply a scattering correction scheme to the ac-9's time-lag, temperature and salinity corrected data. The SeaSoar ac-9 data are scattering corrected according to Roesler and Zaneveld, (1994).

The Roesler and Zaneveld scattering correction method is performed by first calculating a first order scattering spectrum, $b'(\lambda)$,

$$b'(\lambda) = c_{TS}(\lambda) - a_{TS}(\lambda)$$

The scattering correction method assumes that there is no absorption at 715 nm and that any value associated with $a_{TS}(715)$ is due to scattering, but at all other wavelengths, some fraction of the detected absorption signal is due to scattering. Therefore, the shape of the first order scattering spectrum, $b'(\lambda)$ weighted by the reference wavelength, $a(715)$, is used to

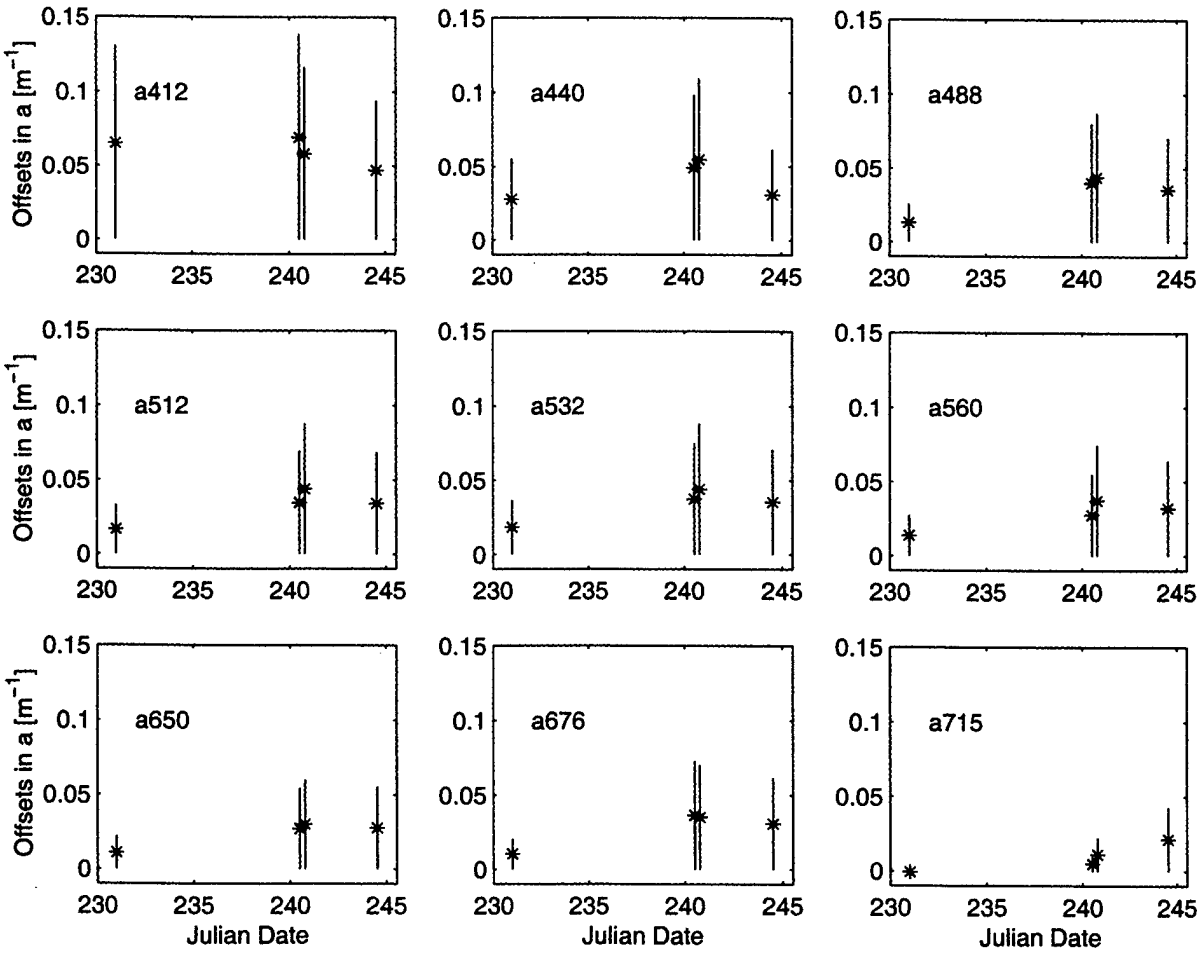



Figure 9: Post-calibration offsets in absorption spectra as a function of time. Identical criteria for the calculation of the post-calibration offsets in $c(\lambda)$ were also applied towards the calculation of the post-calibration offsets in $a(\lambda)$.

remove scattering errors in the detected absorption measurement. The temperature, salinity and scattering corrected absorption coefficients, which are the "true" absorption coefficients, are then:

$$a(\lambda) = a_{TS}(\lambda) - b'(\lambda)*[a_{TS}(715)/\ b'(715)]$$

The true scattering coefficients can then be determined from the temperature and salinity corrected attenuation and the temperature, salinity and scattering corrected absorption:

$$b(\lambda) = c_{TS}(\lambda) - a(\lambda)$$

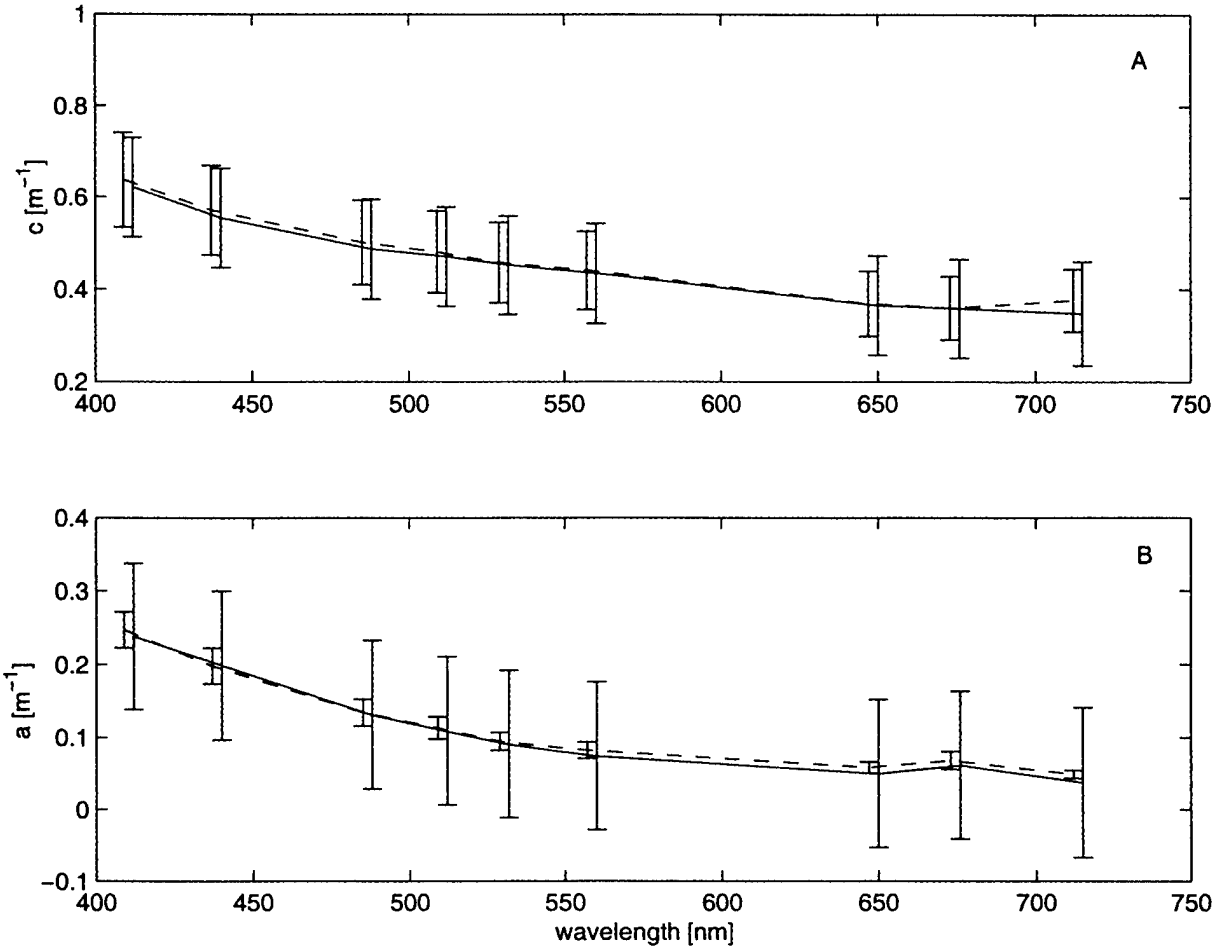



Figure 10: Comparison of 1-m bin averaged post-calibrated SeaSoar (solid) and temperature and salinity corrected Slow-Drop (dashed) spectra for E9608 butterfly 2 line N-S at 20 m. The Slow-Drop spectrum is shifted 3 nm to the left to make the standard deviations distinguishable.

The application of the scattering correction to the temperature and salinity corrected, post-calibrated SeaSoar data is illustrated in the following section.

## 3.7 Editing

The IOP data files, after processing, are edited to eliminate spectra containing data spikes and data with erroneous GPS values. An adjustment for only the E9608 data collected during optical path clouding of the $a$ or $c$ flow tubes is also performed when necessary.

The elimination of data spikes is accomplished by requiring the data to satisfy the following criteria: 1) $a$ and $c$ must be non-negative and less than some large, rare value (e.g. 10 $m^{-1}$); 2) data must not exhibit a variance that exceeds a pre-determined variance value. The variance in the data was calculated using a 5-point running mean. The cut-off variance value for E9608 data was 0.002 and 0.04 $m^{-2}$ for $a$ and $c$, respectively, and for E9704, 0.0015

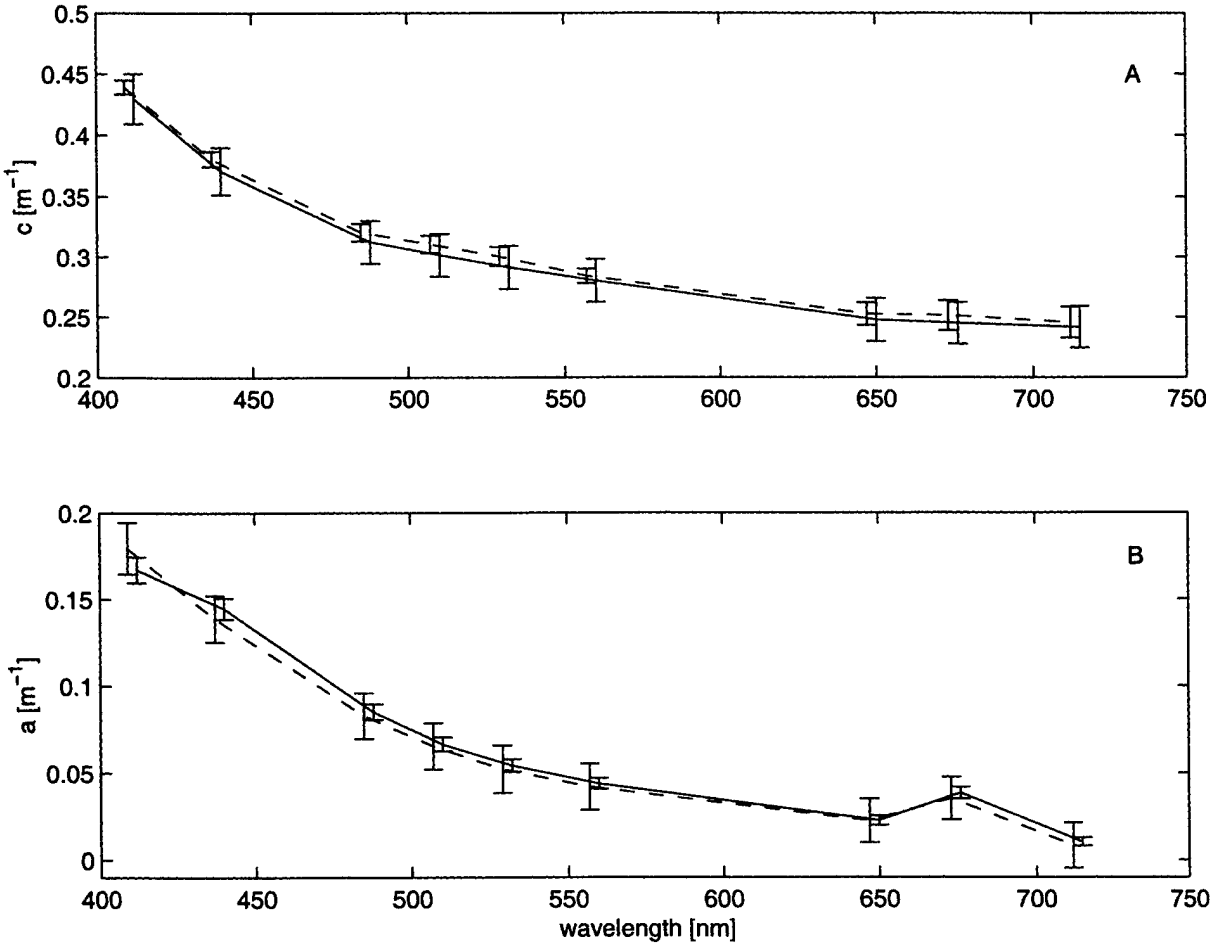



Figure 11: Comparison of post-calibrated SeaSoar (solid) and temperature and salinity corrected Slow-Drop (dashed) spectra for E9704 smallbox 3 line 3 at 20 m. The Slow-Drop spectrum is shifted 3 nm to the left to make the standard deviations distinguishable.

and 0.01 $m^{-2}$ for $a$ and $c$, respectively. The cut-off variance values chosen were of three orders of magnitude or greater than the average variance exhibited by the data, which translates to $a$ and $c$ values an order of magnitude larger than the mean value. Incorrect recordings of GPS values were found in several data files. These data, constituting less than 1% of the total data file, were eliminated.

On several occassions during the E9608 cruise, either or both the $a$ and/or $c$ flow tube(s) inefficiently cleared opaque materials (e.g. gelatinous zooplankton) from the optical paths. The resultant measured IOP exhibited a jump or discontinuity, which was an approximately constant offset in the magnitude. For these cases, adjustments to the data were performed in order to salvage qualitative data of the IOP distributions. The offset adjustment was partially unsuccessful in the preservation of spectral shapes, while the absolute magnitudes of the optical parameters were not retrievable with a high degree of confidence. The offset adjustment enabled "clouded" IOP data to be comparable to data on either side of the

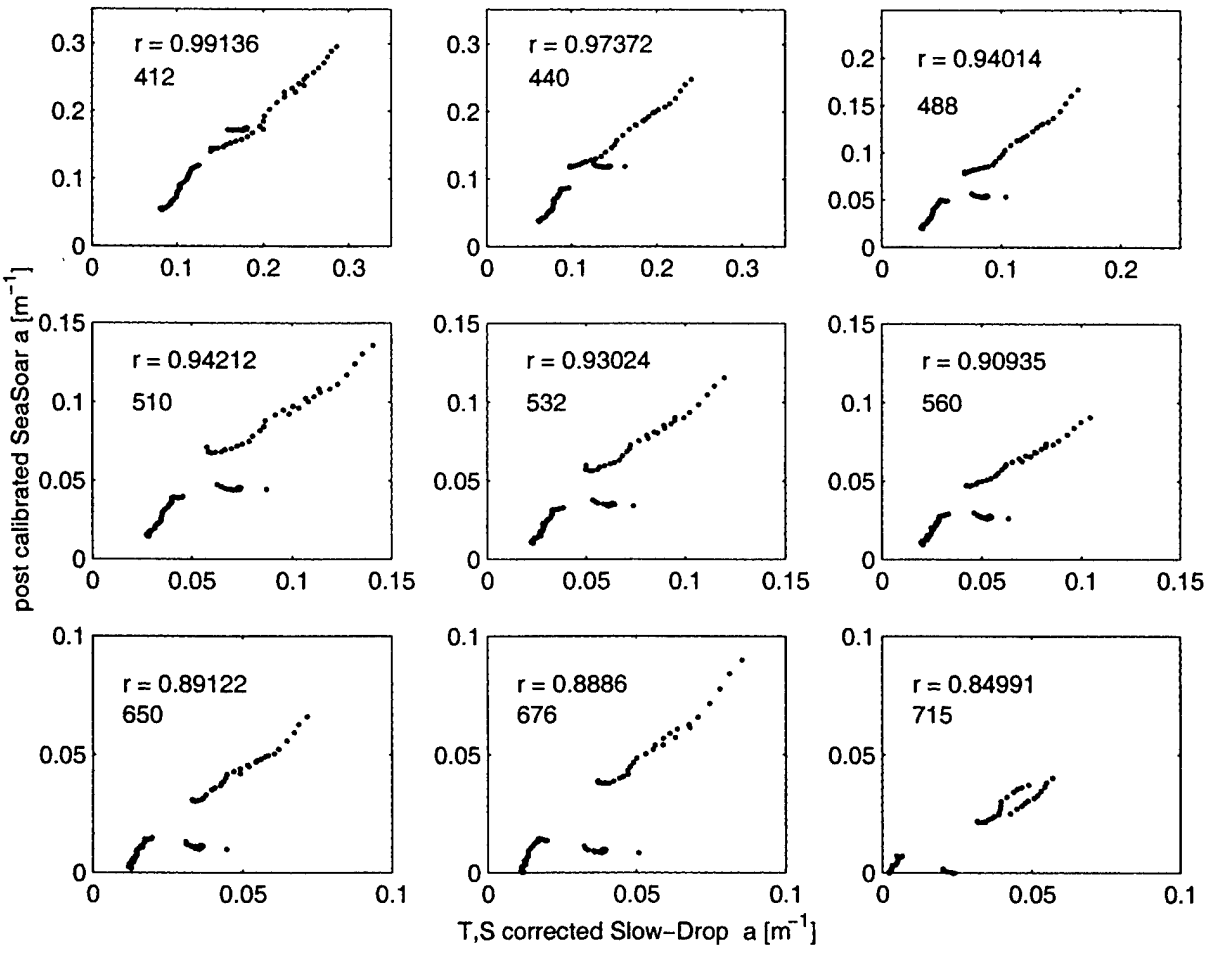



Figure 12: Plots of E9608 post-calibrated SeaSoar absorption coefficients ($m^{-1}$) regressed against Slow-Drop attenuation coefficients ($m^{-1}$). Text in each panel states the calculated correlation coefficient and wavelength. post-calibration of deep "clear" water values was the least precise.

corrected period. The data adjustment was performed by first identifying the start and stop time of the clog during the E9608 cruise (Table 2). Each section(line) of a cross-shelf box survey was averaged and plotted as a function of bottom bathymetry[1]. The IOP cross-shelf sections of the box pattern were then averaged together to obtain an ensemble mean $a$ and/or $c$ as a function of bottom depth (or equivalently, cross-shelf distance) for each box. The calculated ensemble mean as a function of bottom depth is used to determine the magnitude of the offset for each "clouded" data point (offset = "clouded" data value − ensemble mean value). Since this offset is approximately constant, a mean offset was calculated from all the individually calculated offsets. The removal of the mean offset is expected to correct the optical measurements corrupted by a clouding substance. Data which could not be adjusted

[1]Bottom bathymetry was obtained from an awk subroutine written by S. Pierce that utilizes latitude and longitude coordinates as input to produce bottom depth corresponding to unpublished USGS bottom bathymetry archives compiled by Rich Signell in 1996.

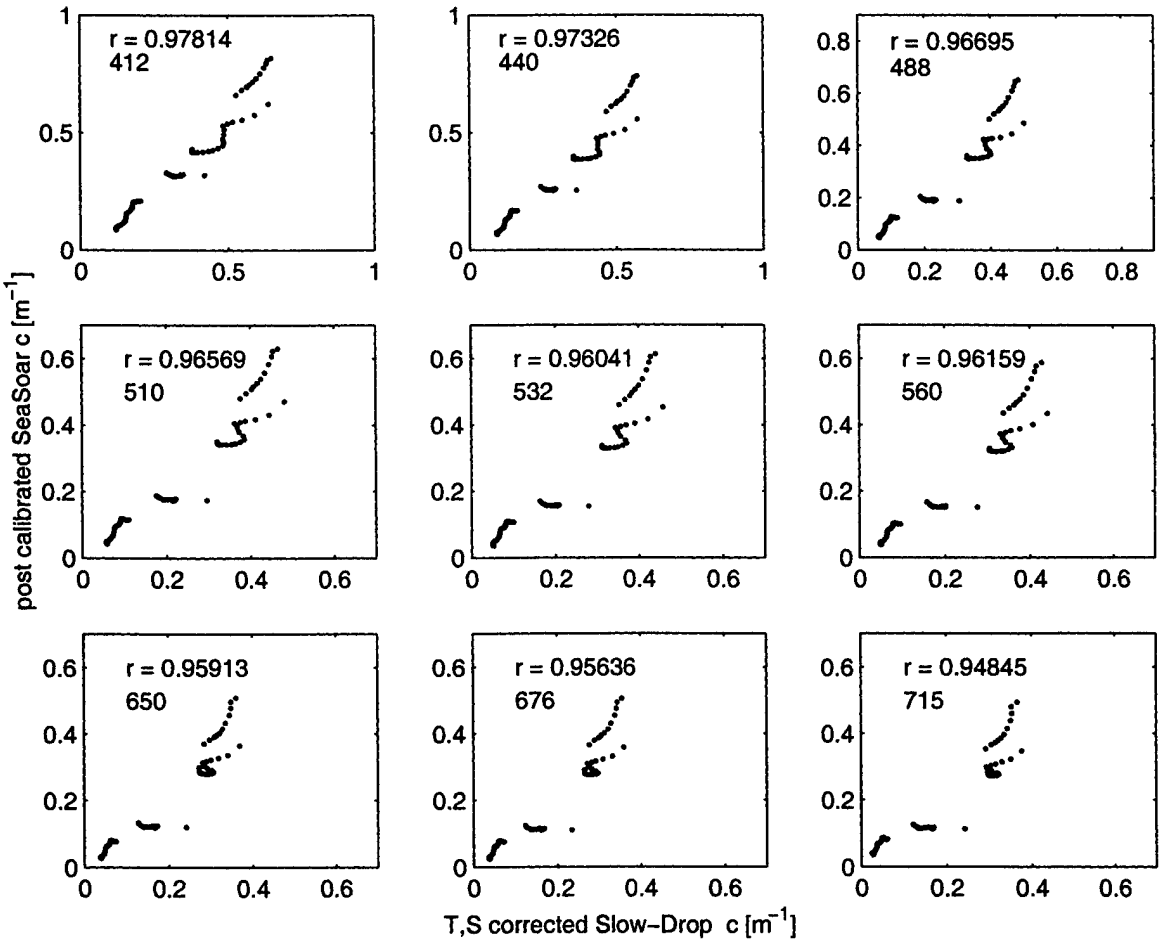



Figure 13: Plots of E9608 post-calibrated SeaSoar attenuation coefficients ($m^{-1}$) regressed against Slow-Drop attenuation coefficients ($m^{-1}$). Text in each panel states the calculated correlation coefficient and wavelength. post-calibration of deep "clear" water values was the least precise.

were completely eliminated from the final version of the data file. While data which have undergone this adjustment is not absolutely correct, this correction preserves important spatial information of optical properties. Table 2 summarizes the start and stop times of the "clouding" events, the duration of the "clouding" event and the percentage of the data which was salvaged by the adjustment method previously described. The "clouded" data constitute approximately 12% of the entire E9608 cruise data set.

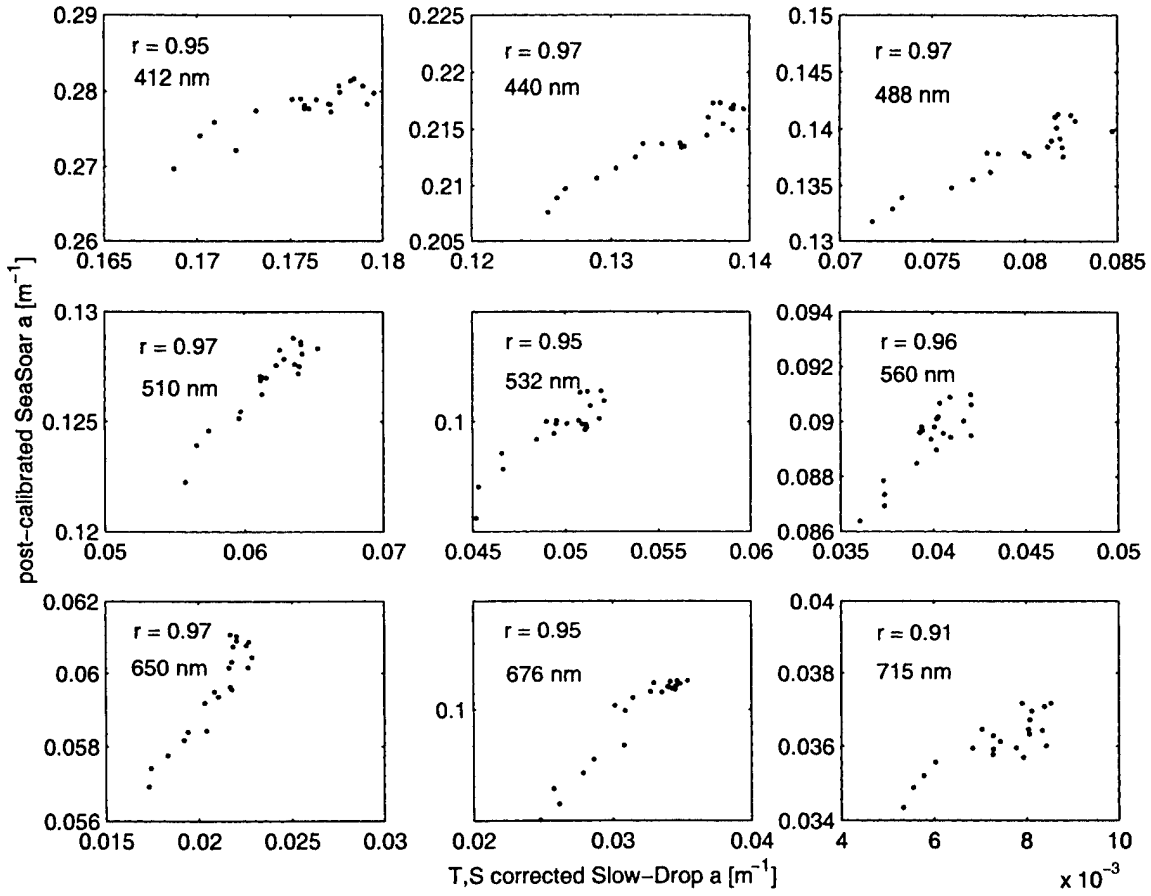



Figure 14: Plots of E9704 post-calibrated SeaSoar attenuation coefficients ($m^{-1}$) regressed against Slow-Drop absorption coefficients ($m^{-1}$). Text in each panel states the calculated correlation coefficient and wavelength.

Table 2. E9608 ac-9 clouding events

| Section | Start Time | Section | Stop Time | Duration (HH:MM) | Percent recovered |
|---|---|---|---|---|---|
| bigbox 2, line B | 21-Aug-96 00:14:24 | bigbox 2, line C1 | 21-Aug-96 09:59:02 | 9:45 | 100 |
| smallbox 5 to smallbox 6 | 26-Aug-96 01:29:08 | smallbox 6, line 6 | 26-Aug-96 04:22:13 | 3:07 | 91 |
| smallbox 7, line 4 | 29-Aug-96 09:49:49 | smallbox 7, line 3 | 29-Aug-96 13:25:06 | 3:17 | 92 |
| smallbox 8, line 6 | 29-Aug-96 21:55:26 | smallbox 8, line 4-5 | 30-Aug-96 01:56:21 | 4:01 | 15 |
| smallbox 8, line 3 | 30-Aug-96 06:59:20 | smallbox 8, line 1 | 30-Aug-96 10:32:53 | 4:27 | 83 |
| bigbox 3, line C0 | 31-Aug-96 05:52:36 | bigbox 3, line C0 | 31-Aug-96 07:55:39 | 2:03 | 0 |

Flags are included in each data file to indicate editing performed on the data, as well as the percentage of data which has been discarded from the processed file. The flags are located

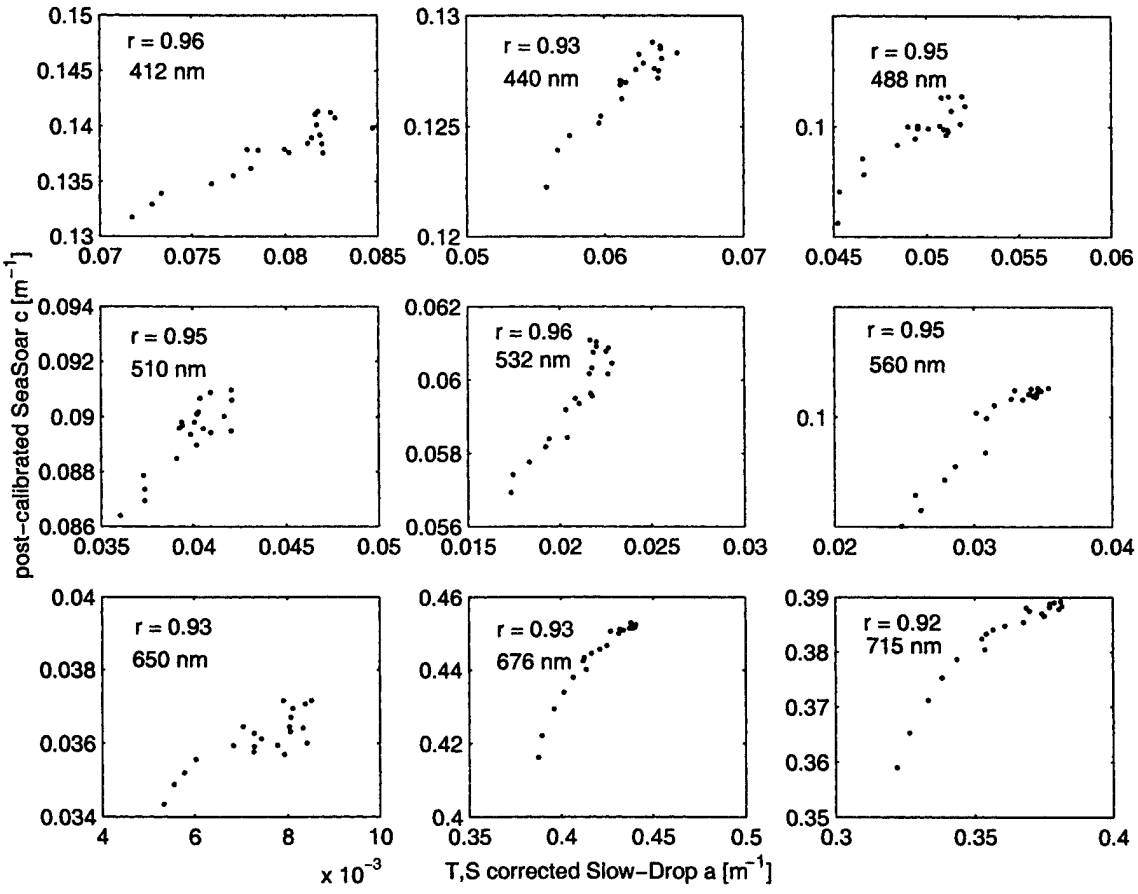



Figure 15: Plots of E9704 post-calibrated SeaSoar attenuation coefficients ($m^{-1}$) regressed against Slow-Drop attenuation coefficients ($m^{-1}$). Text in each panel states the calculated correlation coefficient and wavelength.

in the first three rows of the 26th column of the data file: the editing flags are encoded on the first row (see next paragraph), the second flag indicates the presence of a missing value flag within the data record (i.e. a non-zero value indicates that the missing value, 1.0e+22, was used to substitute for discarded values), and the third flag indicates the percentage of the 1-s binned, unedited data that was removed during the editing process.

The editing flag consists of 9 numeric characters and are either "0" or "1". The first and ninth values are "1" and serve as place holders. A non-zero second character indicates incomplete spectra were found in the raw file and removed. A non-zero third character indicates negative IOP values were removed. A non-zero fourth character indicates the removal of a data spike (following a predetermined cut-off value, $a(\lambda)=c(\lambda)=10$). A non-zero fifth character indicates $c$ values were discarded because $c$ values were associated with a variance that exceeded the cut-off variance value for $c$. A non-zero sixth character indicates $a$ values were discarded because $a$ values were associated with a variance that exceeded the

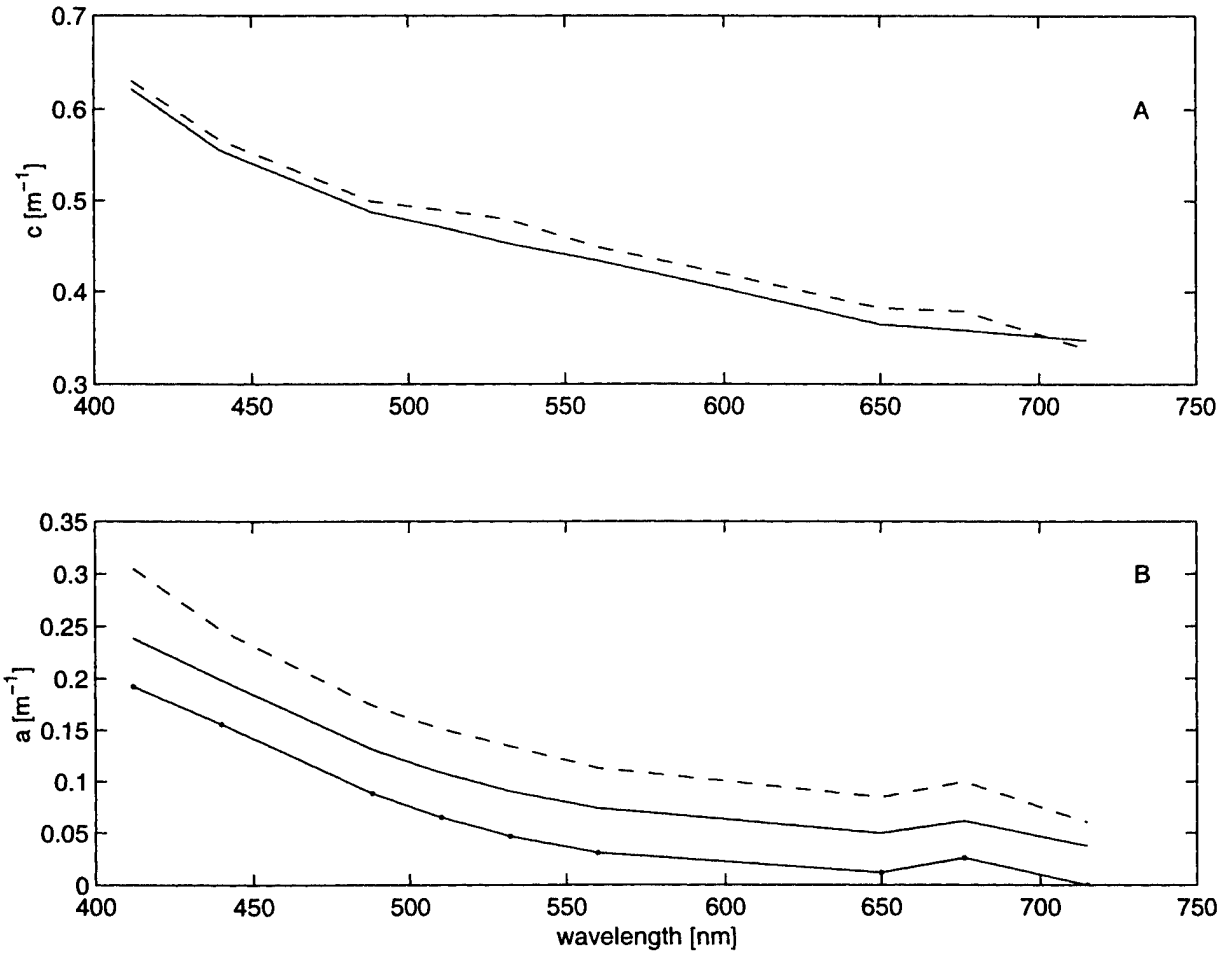



Figure 16: SeaSoar ac-9 attenuation (A) and absorption (B) spectra (e9608 Butterfly 2, line N-S at 20 m) that are temperature and salinity corrected (dashed) are then post-calibrated (solid). Absorption spectra are further corrected to remove errors due to scattering (dotted solid line)

cut-off variance value for $a$. A non-zero seventh character indicates a file has been edited to remove data merged with incorrect GPS values. A non-zero eighth character indicates the data has been adjusted to correct a "jump" in the data due to optical path clouding in the flow tubes.

For example, a data file having the 26th column and its first three elements,

101101001
1.0e+22
1.23

would indicate by the first row, (1) no missing values were inserted in the data file; (2) negative IOP values were found and removed; (3) data spikes were removed; (4) there were no $c$ values were associated with an anomalously excessive variance; (5) $a$ values were removed for having an associated anomalously excessive variance; (6) no GPS errors were found in the raw data file; (7) no adjustment in the data was performed to adjust for a "clouding" event. In the second row, a non-zero value indicates that missing values exist in the data file and are flagged by the value, 1.0e+22. In the third row, 1.23% of the original data file that was eliminated after the entire editing procedure.

While our rapid physical and bio-optical surveys involved the towed, undulating vehicle SeaSoar, the techniques described here for producing reliable multi-wavelength bio-optical measurements are equally valid for other towed systems (e.g., Guildline Instrument's Mini-BAT; Geological and Marine Instrumentation's Scanfish; Chelsea Instrument's Nu Shuttle and Aquashuttle) and autonomous underwater vehicles. These measurement platforms and bio-optical instruments of increasing capability (complexity) are being used ever more frequently. With proper care, they can be used to rapidly characterize three-dimensional physical and bio-optical property distributions.

# 4 Data Presentation

The final, processed and edited inherent optical property data files were used to generate the plots of representative spectra, contoured maps and contoured sections presented later in the report. Contour maps were created by gridding the data using "zgrid" (Crain, 1968, unpublished). Any grid point more than two grid points away from a data point was set to be undefined. The $a(676)$,$a(440)$ and $c(650)$ were chosen to show phytoplankton, combined contributions of absorbing components (non-phytoplankton particulate matter, phytoplankton and colored dissolved organic matter) and sediment distributions, respectively. The reader should note that the magnitude is proportional to the concentration of the absorbing substances. Bio-optical models can be applied to $a(676)$ to retrieve estimates of chlorophyll a concentrations in units of mg/m$^3$ (e.g. Morel and Bricaud, 1981; Cleveland, 1995).

## 4.1 Spectra

The volume of optical data associated with the SeaSoar surveys makes the display of $a$ and $c$ as a function of wavelength impractical. Therefore, only representative spectra from the beginning, middle and end of the E9608 and E9704 cruises are included in this report. The spectra are averages between the isopycnals $\sigma_t = 24.2 \pm 0.025$ kg/m$^3$, for the E9608 cruise and $\sigma_t = 25.4 \pm 0.025$ kg/m$^3$, for the E9704 cruise. These isopycnals roughly correspond to 20-30 meters depth.

## 4.2 Maps

Maps of inherent optical properties are presented for each parameter, $a(676)$, $a(440)$ and $c(650)$, at four different levels as a function of latitude and longitude. The four different levels were chosen to display: 1) representative surface (z = 5 m), 2) subsurface chlorophyll maxima ($\sigma_t = 24.6 \pm 0.025$ kg/m$^3$ (E9608) and $\sigma_t = 25.4 \pm 0.025$ kg/m$^3$ (E9704), z $\approx$ 20-30 m), 3) mid-depth (z = 45 m) and 4) near bottom sediment layer IOP distributions (z = 15 m above bottom). The four panels are presented clockwise, starting at the upper left, respectively. The top label is the survey pattern name, the wavelength and date.

## 4.3 Sections

The sections, or lines, of a survey pattern are presented as plots of $a(676)$, $a(440)$ and $c(650)$ as a function of depth (pressure) and latitude (cross-shelf distance). The top label identifies the survey pattern. The name, average longitude and time of the section are printed above each column of $a(676)$, $a(440)$ and $c(650)$.

# 5 Acknowledgements

The authors wish to thank: the Oregon State University Marine Technicians, M. Willis and L. Fayler, who were responsible for the highly successful SeaSoar operations. The officers and crew of the *R/V Endeavor* performed superbly, allowing us to tow SeaSoar through a region with considerable fishing activity and ship traffic. C. Moore (WET Labs, Inc.) provided valuable assistance with installing the ac-9 on SeaSoar. Thanks to S. Pegau and R. Zaneveld for providing their profiling ac-9 data for comparison with our SeaSoar ac-9 data and for helpful discussions on ac-9 data processing. Thanks to S. Pegau, C. Roesler, A. Barnard and E. Boss for helpful discussions on ac-9 data quality control. T. Ebling created the ac-9 realtime display and monitoring software by adapting the code originally written by N. Potter for use with T. Cowles's towed multiwavelength fluorescence instrument. This work was funded by the Office of Naval Research Grant N00014-95-1-0382.

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# 7 Section Times and Cruise Tracks

## 7.1 E9608

E9608 Section Times

| | section name | start time | stop time |
|---|---|---|---|
| **Small Box 1** | line1 | 15-Aug-96 23:20:18 | 16-Aug-96 01:59:54 |
| | line1_2 | 16-Aug-96 01:59:55 | 16-Aug-96 02:23:46 |
| | line2 | 16-Aug-96 02:39:56 | 16-Aug-96 04:19:04 |
| | line2_3 | 16-Aug-96 04:19:05 | 16-Aug-96 04:44:54 |
| | line3 | 16-Aug-96 04:44:55 | 16-Aug-96 07:01:37 |
| | line3_4 | 16-Aug-96 07:01:38 | 16-Aug-96 07:30:59 |
| | line4a | 16-Aug-96 07:31:00 | 16-Aug-96 08:36:09 |
| | line4b | 16-Aug-96 09:39:42 | 16-Aug-96 10:35:54 |
| | line4_5 | 16-Aug-96 10:35:55 | 16-Aug-96 11:13:50 |
| | line5 | 16-Aug-96 11:13:51 | 16-Aug-96 13:10:14 |
| | line5_6 | 16-Aug-96 13:10:15 | 16-Aug-96 13:38:06 |
| | line6 | 16-Aug-96 13:38:07 | 16-Aug-96 15:27:16 |
| **Big Box 1** | lineF | 17-Aug-96 02:00:01 | 17-Aug-96 06:10:49 |
| | lineE_F | 17-Aug-96 06:10:50 | 17-Aug-96 07:00:21 |
| | lineE | 17-Aug-96 07:00:22 | 17-Aug-96 12:42:01 |
| | lineD_E | 17-Aug-96 12:50:43 | 17-Aug-96 13:42:58 |
| | lineD | 17-Aug-96 13:42:59 | 17-Aug-96 19:24:19 |
| | lineC_D | 17-Aug-96 19:24:20 | 17-Aug-96 20:11:58 |
| | lineC | 17-Aug-96 20:11:59 | 18-Aug-96 00:36:39 |
| | lineB_C | 18-Aug-96 00:36:40 | 18-Aug-96 01:28:16 |
| | lineB | 18-Aug-96 01:28:17 | 18-Aug-96 07:21:50 |
| | bb1_sb2 | 18-Aug-96 08:28:01 | 18-Aug-96 09:07:44 |
| **Small Box 2** | line1 | 18-Aug-96 09:35:18 | 18-Aug-96 11:31:21 |
| | line1_2 | 18-Aug-96 11:31:22 | 18-Aug-96 11:59:06 |
| | line2 | 18-Aug-96 11:59:07 | 18-Aug-96 13:44:25 |
| | line2_3 | 18-Aug-96 13:44:26 | 18-Aug-96 14:12:57 |
| | line3 | 18-Aug-96 14:12:58 | 18-Aug-96 16:06:00 |
| | line3_4 | 18-Aug-96 17:07:09 | 18-Aug-96 17:35:17 |
| | line4 | 18-Aug-96 18:02:09 | 18-Aug-96 19:42:21 |
| | line4_5 | 18-Aug-96 19:42:22 | 18-Aug-96 20:06:23 |
| | line5 | 18-Aug-96 21:06:45 | 18-Aug-96 23:12:05 |
| | line5_6 | 18-Aug-96 23:12:06 | 18-Aug-96 23:46:51 |
| | line6 | 18-Aug-96 23:46:52 | 19-Aug-96 01:45:26 |
| | sb2_sb3 | 19-Aug-96 01:45:27 | 19-Aug-96 03:08:38 |
| **Small Box 3** | line6 | 20-Aug-96 01:39:27 | 20-Aug-96 03:27:23 |
| | line5_6 | 20-Aug-96 03:27:24 | 20-Aug-96 03:56:24 |
| | line5 | 20-Aug-96 03:56:25 | 20-Aug-96 05:40:13 |
| | line4_5 | 20-Aug-96 05:40:14 | 20-Aug-96 06:04:19 |
| | line4 | 20-Aug-96 06:04:20 | 20-Aug-96 07:51:16 |
| | line3_4 | 20-Aug-96 07:51:17 | 20-Aug-96 08:17:15 |
| | line3 | 20-Aug-96 08:17:16 | 20-Aug-96 10:05:16 |
| | line2_3 | 20-Aug-96 10:05:17 | 20-Aug-96 10:30:04 |
| | line2 | 20-Aug-96 10:30:05 | 20-Aug-96 12:13:46 |
| | line1_2 | 20-Aug-96 12:13:47 | 20-Aug-96 12:48:18 |
| | line1 | 20-Aug-96 12:48:19 | 20-Aug-96 14:40:19 |

E9608 Section Times (continued)

| | section name | start time | stop time |
|---|---|---|---|
| **Big Box 2** | lineA | 20-Aug-96 17:03:21 | 20-Aug-96 22:18:46 |
| | lineA_B | 20-Aug-96 22:18:47 | 20-Aug-96 23:06:20 |
| | lineB | 20-Aug-96 23:06:21 | 21-Aug-96 04:53:03 |
| | lineB_C | 21-Aug-96 04:53:04 | 21-Aug-96 05:43:16 |
| | lineC1 | 21-Aug-96 05:43:17 | 21-Aug-96 11:11:17 |
| | lineC2 | 21-Aug-96 13:01:22 | 21-Aug-96 19:35:29 |
| | lineC_D | 21-Aug-96 19:35:30 | 21-Aug-96 20:23:40 |
| | lineD | 21-Aug-96 20:23:41 | 21-Aug-96 21:58:43 |
| **Small Box 4** | line6 | 24-Aug-96 20:01:44 | 24-Aug-96 22:14:03 |
| | line5_6 | 24-Aug-96 22:14:04 | 24-Aug-96 22:42:18 |
| | line5 | 24-Aug-96 22:42:19 | 25-Aug-96 00:27:36 |
| | line4_5 | 25-Aug-96 00:27:37 | 25-Aug-96 00:51:36 |
| | line4 | 25-Aug-96 00:51:37 | 25-Aug-96 02:37:21 |
| | line3_4 | 25-Aug-96 02:37:22 | 25-Aug-96 03:01:10 |
| | line3 | 25-Aug-96 03:01:11 | 25-Aug-96 04:55:27 |
| | line2_3 | 25-Aug-96 04:55:28 | 25-Aug-96 05:18:58 |
| | line2 | 25-Aug-96 05:18:59 | 25-Aug-96 07:07:04 |
| | line1_2 | 25-Aug-96 07:07:05 | 25-Aug-96 07:30:20 |
| | line1 | 25-Aug-96 07:30:21 | 25-Aug-96 09:21:25 |
| | sb4_sb5 | 25-Aug-96 09:21:26 | 25-Aug-96 11:34:55 |
| **Small Box 5** | line6 | 25-Aug-96 11:34:56 | 25-Aug-96 13:31:44 |
| | line5_6 | 25-Aug-96 13:31:45 | 25-Aug-96 13:59:09 |
| | line5 | 25-Aug-96 13:59:10 | 25-Aug-96 15:52:39 |
| | line4_5 | 25-Aug-96 15:52:40 | 25-Aug-96 16:17:11 |
| | line4 | 25-Aug-96 16:17:12 | 25-Aug-96 18:14:59 |
| | line3_4 | 25-Aug-96 18:15:00 | 25-Aug-96 18:38:20 |
| | line3 | 25-Aug-96 18:38:21 | 25-Aug-96 20:24:41 |
| | line2_3 | 25-Aug-96 20:24:42 | 25-Aug-96 20:51:21 |
| | line2 | 25-Aug-96 20:51:22 | 25-Aug-96 22:48:44 |
| | line1_2 | 25-Aug-96 22:48:45 | 25-Aug-96 23:14:43 |
| | line1 | 25-Aug-96 23:14:44 | 26-Aug-96 01:05:56 |
| | sb5_sb6 | 26-Aug-96 01:05:57 | 26-Aug-96 03:11:38 |
| **Small Box 6** | line6 | 26-Aug-96 03:11:39 | 26-Aug-96 04:55:38 |
| | line5_6 | 26-Aug-96 04:55:39 | 26-Aug-96 05:20:15 |
| | line5 | 26-Aug-96 05:20:16 | 26-Aug-96 07:08:54 |
| | line4_5 | 26-Aug-96 07:08:55 | 26-Aug-96 07:31:14 |
| | line4 | 26-Aug-96 07:31:15 | 26-Aug-96 09:30:49 |
| | line3_4 | 26-Aug-96 09:30:50 | 26-Aug-96 09:57:15 |
| | line3 | 26-Aug-96 09:57:16 | 26-Aug-96 11:48:17 |
| | line2_3 | 26-Aug-96 11:48:18 | 26-Aug-96 12:14:25 |
| | line2 | 26-Aug-96 12:14:26 | 26-Aug-96 14:21:14 |
| | line1_2 | 26-Aug-96 14:21:15 | 26-Aug-96 14:48:22 |
| | line1 | 26-Aug-96 14:48:23 | 26-Aug-96 16:53:29 |
| **Butterfly 1** | weA | 26-Aug-96 23:59:40 | 27-Aug-96 00:59:48 |
| | weB | 27-Aug-96 04:05:59 | 27-Aug-96 05:25:22 |
| | en | 27-Aug-96 05:25:23 | 27-Aug-96 07:16:07 |
| | ns | 27-Aug-96 07:16:08 | 27-Aug-96 09:46:25 |
| | sw | 27-Aug-96 09:46:26 | 27-Aug-96 11:12:19 |

E9608 Section Times (continued)

| | section name | start time | stop time |
|---|---|---|---|
| **Butterfly 2** | we | 27-Aug-96 11:12:20 | 27-Aug-96 14:15:11 |
| | en0 | 27-Aug-96 14:15:12 | 27-Aug-96 14:51:30 |
| | en1 | 27-Aug-96 14:51:31 | 27-Aug-96 15:22:20 |
| | en | 27-Aug-96 15:22:21 | 27-Aug-96 17:31:05 |
| | ns | 27-Aug-96 17:31:06 | 27-Aug-96 20:00:15 |
| | sw | 27-Aug-96 20:00:16 | 27-Aug-96 21:28:56 |
| **Butterfly 3** | we | 27-Aug-96 23:52:14 | 28-Aug-96 02:36:24 |
| | en | 28-Aug-96 02:36:25 | 28-Aug-96 04:48:56 |
| | ns | 28-Aug-96 04:48:57 | 28-Aug-96 07:19:26 |
| | sw | 28-Aug-96 07:19:27 | 28-Aug-96 08:51:39 |
| **Butterfly 4** | line1_4 | 28-Aug-96 09:41:28 | 28-Aug-96 11:09:23 |
| | ns | 28-Aug-96 11:09:24 | 28-Aug-96 14:53:05 |
| | sn | 28-Aug-96 14:53:06 | 28-Aug-96 17:09:54 |
| **Solitons** | a | 28-Aug-96 17:09:55 | 28-Aug-96 17:50:39 |
| | b | 28-Aug-96 17:50:40 | 28-Aug-96 18:17:37 |
| | b_c | 28-Aug-96 18:17:38 | 28-Aug-96 18:22:15 |
| | c | 28-Aug-96 18:22:16 | 28-Aug-96 18:58:20 |
| | d | 28-Aug-96 18:58:21 | 28-Aug-96 19:26:34 |
| | e | 28-Aug-96 19:26:35 | 28-Aug-96 19:50:45 |
| | f | 28-Aug-96 19:50:46 | 28-Aug-96 20:15:42 |
| | g | 28-Aug-96 20:15:43 | 28-Aug-96 21:00:00 |
| | h | 28-Aug-96 21:00:01 | 28-Aug-96 22:22:00 |
| | i | 28-Aug-96 22:22:01 | 28-Aug-96 23:36:58 |
| | j | 28-Aug-96 23:36:59 | 29-Aug-96 00:02:32 |
| | k | 29-Aug-96 00:02:33 | 29-Aug-96 00:18:30 |
| | l | 29-Aug-96 00:18:31 | 29-Aug-96 00:23:41 |
| **Small Box 7** | line6 | 29-Aug-96 04:00:03 | 29-Aug-96 05:53:19 |
| | line5_6 | 29-Aug-96 05:53:20 | 29-Aug-96 06:21:21 |
| | line5 | 29-Aug-96 06:55:17 | 29-Aug-96 09:03:37 |
| | line4_5 | 29-Aug-96 09:03:38 | 29-Aug-96 09:28:10 |
| | line4 | 29-Aug-96 09:28:11 | 29-Aug-96 11:33:18 |
| | line3_4 | 29-Aug-96 11:33:19 | 29-Aug-96 11:59:58 |
| | line3 | 29-Aug-96 11:59:59 | 29-Aug-96 13:52:43 |
| | line2_3 | 29-Aug-96 13:52:44 | 29-Aug-96 14:18:42 |
| | line2 | 29-Aug-96 14:18:43 | 29-Aug-96 16:14:56 |
| | line1_2 | 29-Aug-96 16:14:57 | 29-Aug-96 16:42:12 |
| | line1 | 29-Aug-96 16:42:13 | 29-Aug-96 18:50:35 |
| | sb7_sb8 | 29-Aug-96 18:50:36 | 29-Aug-96 21:17:35 |
| **Small Box 8** | line6 | 29-Aug-96 21:17:36 | 29-Aug-96 23:24:30 |
| | line5_6 | 29-Aug-96 23:24:31 | 29-Aug-96 23:53:13 |
| | line5 | 29-Aug-96 23:53:14 | 30-Aug-96 01:44:01 |
| | line4_5 | 30-Aug-96 01:44:02 | 30-Aug-96 02:09:33 |
| | line4 | 30-Aug-96 02:09:34 | 30-Aug-96 04:10:58 |
| | line3_4 | 30-Aug-96 04:10:59 | 30-Aug-96 04:38:14 |
| | line3 | 30-Aug-96 04:38:15 | 30-Aug-96 06:52:04 |
| | line2_3 | 30-Aug-96 06:52:05 | 30-Aug-96 07:19:44 |
| | line2 | 30-Aug-96 07:19:45 | 30-Aug-96 09:16:53 |
| | line1_2 | 30-Aug-96 09:16:54 | 30-Aug-96 09:43:08 |
| | line1 | 30-Aug-96 10:06:17 | 30-Aug-96 12:10:57 |

E9608 Section Times (continued)

| | section name | start time | stop time |
|---|---|---|---|
| **Small Box 9** | line6 | 30-Aug-96 14:52:14 | 30-Aug-96 16:51:13 |
| | line5_6 | 30-Aug-96 16:51:14 | 30-Aug-96 17:19:02 |
| | line5 | 30-Aug-96 17:19:03 | 30-Aug-96 19:23:28 |
| | line4_5 | 30-Aug-96 19:23:29 | 30-Aug-96 19:53:05 |
| | line4 | 30-Aug-96 19:53:06 | 30-Aug-96 21:45:12 |
| | line3_4 | 30-Aug-96 21:45:13 | 30-Aug-96 22:08:56 |
| | line3 | 30-Aug-96 22:08:57 | 30-Aug-96 23:59:22 |
| | line2_3 | 30-Aug-96 23:59:23 | 31-Aug-96 00:26:12 |
| | line2 | 31-Aug-96 00:26:13 | 31-Aug-96 02:29:09 |
| | line1_2 | 31-Aug-96 02:29:10 | 31-Aug-96 02:57:00 |
| | line1 | 31-Aug-96 02:57:01 | 31-Aug-96 04:53:39 |
| | sb9_bb3 | 31-Aug-96 04:53:40 | 31-Aug-96 05:49:02 |
| **Big Box 3** | lineC0 | 31-Aug-96 05:49:03 | 31-Aug-96 08:02:39 |
| | lineC1 | 31-Aug-96 09:00:40 | 31-Aug-96 14:28:56 |
| | lineC_Ds | 31-Aug-96 14:28:57 | 31-Aug-96 15:19:51 |
| | lineDs | 31-Aug-96 15:23:45 | 31-Aug-96 19:00:59 |
| | lineD_Es | 31-Aug-96 19:01:00 | 31-Aug-96 20:06:29 |
| | lineEs | 31-Aug-96 20:06:30 | 31-Aug-96 23:29:47 |
| | lineE_Fs | 31-Aug-96 23:29:48 | 01-Sep-96 00:21:49 |
| | lineF | 01-Sep-96 00:21:50 | 01-Sep-96 04:46:06 |
| | lineE_Fn | 01-Sep-96 04:46:07 | 01-Sep-96 05:37:24 |
| | lineEn | 01-Sep-96 05:37:25 | 01-Sep-96 06:13:59 |
| | lineD_En | 01-Sep-96 06:14:00 | 01-Sep-96 07:05:38 |
| | lineDn | 01-Sep-96 07:05:39 | 01-Sep-96 07:45:11 |
| | lineC_Dn | 01-Sep-96 07:45:12 | 01-Sep-96 08:32:33 |
| | lineC2 | 01-Sep-96 08:32:34 | 01-Sep-96 11:08:14 |

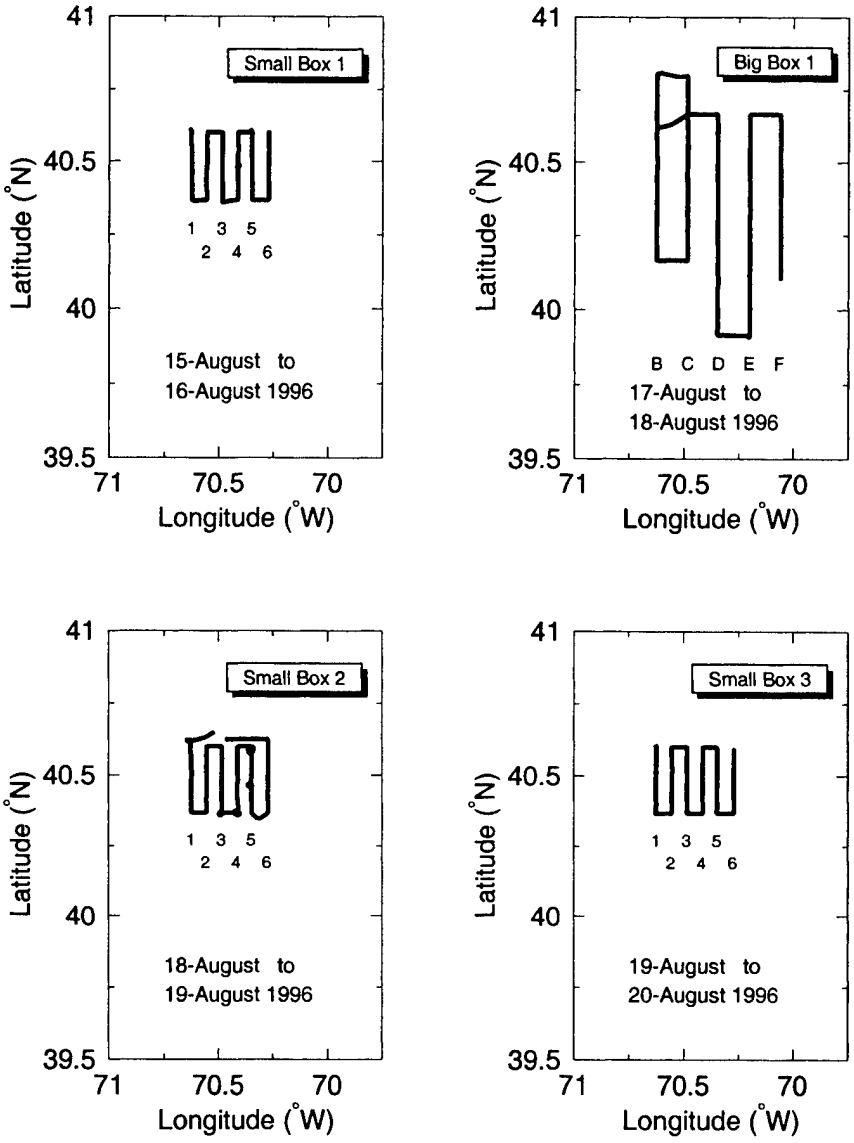



Figure 17: a: Cruise tracks during the E9608 SeaSoar surveys.

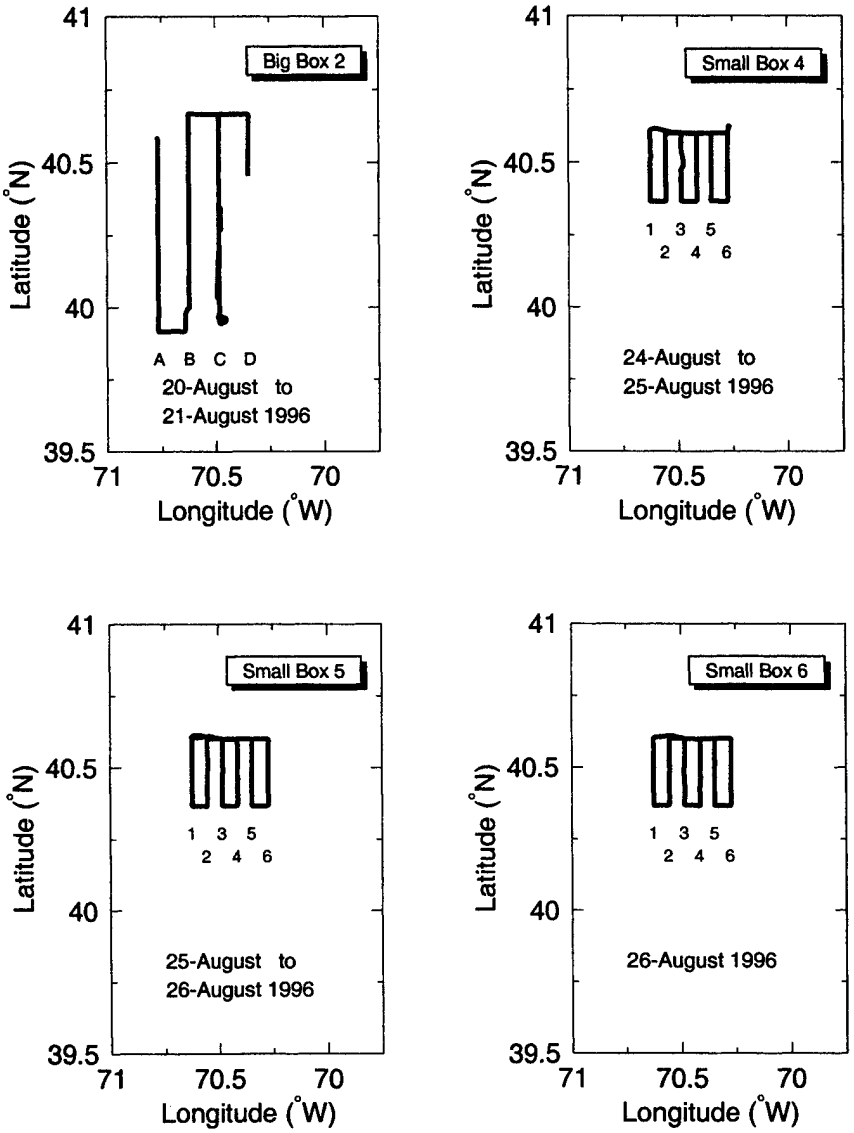



Figure 18: b: Cruise tracks during the E9608 SeaSoar surveys.

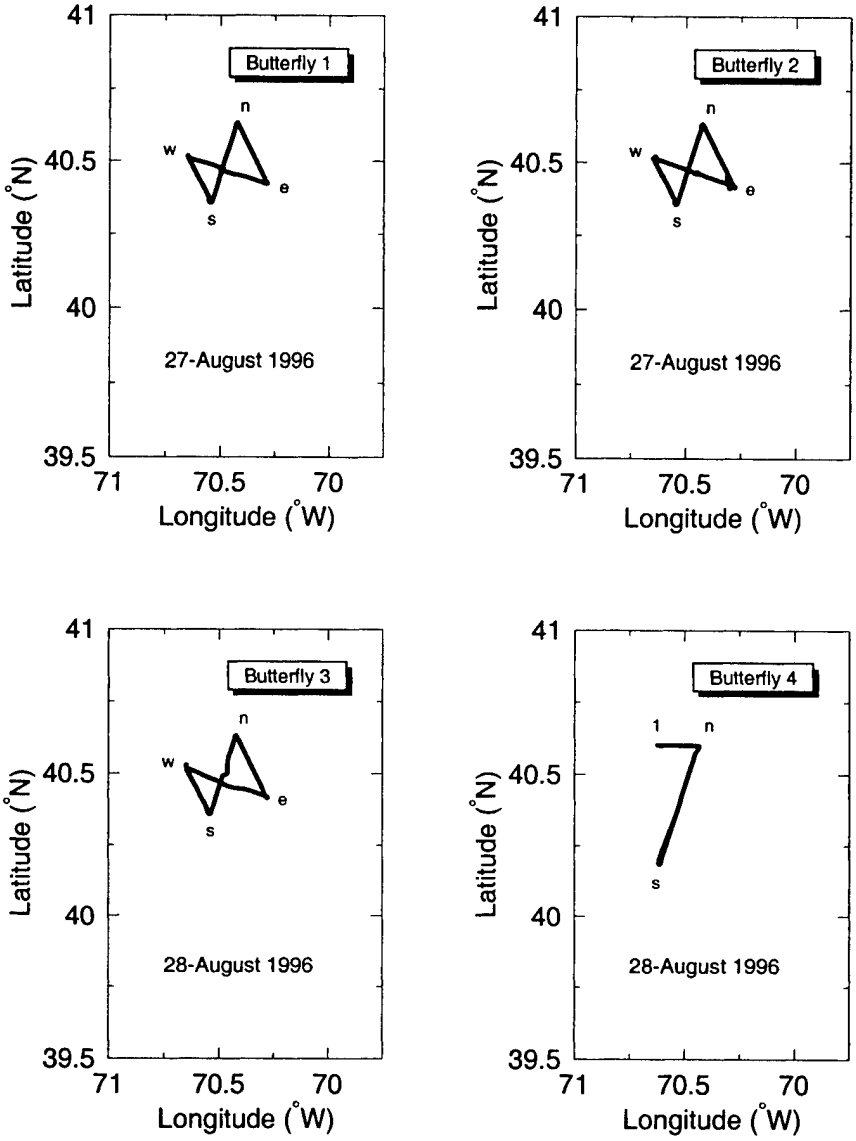



Figure 19: c: Cruise tracks during the E9608 SeaSoar surveys.

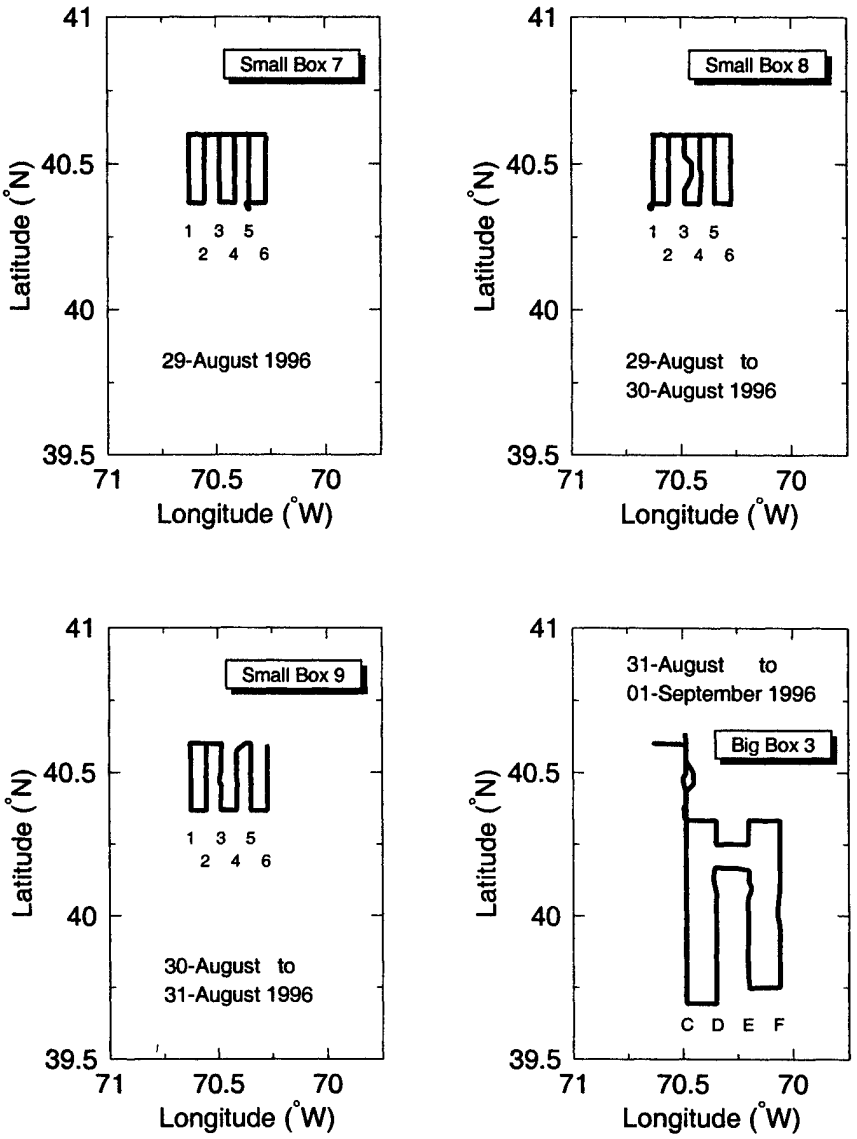



Figure 20: d: Cruise tracks during the E9608 SeaSoar surveys.

## 7.2 E9704

E9704 Section Times

| | section name | start time | stop time |
|---|---|---|---|
| **Small Box 1** | line6 | 27-Apr-97 00:45:09 | 27-Apr-97 03:36:16 |
| | line5_6 | 27-Apr-97 03:36:17 | 27-Apr-97 04:17:47 |
| | line5 | 27-Apr-97 04:17:48 | 27-Apr-97 07:18:30 |
| | line4_5 | 27-Apr-97 07:18:31 | 27-Apr-97 07:45:10 |
| | line4 | 27-Apr-97 07:45:11 | 27-Apr-97 09:35:28 |
| | line3_4 | 27-Apr-97 09:35:29 | 27-Apr-97 10:01:16 |
| | line3 | 27-Apr-97 10:01:17 | 27-Apr-97 12:31:48 |
| **Small Box 2** | lineB | 27-Apr-97 22:27:00 | 28-Apr-97 01:37:23 |
| | line1 | 28-Apr-97 01:46:28 | 28-Apr-97 03:49:47 |
| | line1-2 | 28-Apr-97 03:49:48 | 28-Apr-97 04:19:01 |
| | line2 | 28-Apr-97 04:19:02 | 28-Apr-97 06:24:10 |
| | line2_3 | 28-Apr-97 06:24:11 | 28-Apr-97 06:53:27 |
| | line3 | 28-Apr-97 06:53:28 | 28-Apr-97 09:29:11 |
| | line3_4 | 28-Apr-97 09:29:12 | 28-Apr-97 09:57:09 |
| | line4 | 28-Apr-97 09:57:10 | 28-Apr-97 11:52:14 |
| | line4_5 | 28-Apr-97 11:52:15 | 28-Apr-97 12:20:59 |
| | line5 | 28-Apr-97 12:21:00 | 28-Apr-97 14:36:18 |
| **Small Box 3** | line6a | 29-Apr-97 01:13:35 | 29-Apr-97 03:27:24 |
| | line6b | 29-Apr-97 03:36:08 | 29-Apr-97 05:45:12 |
| | line5_6 | 29-Apr-97 05:45:13 | 29-Apr-97 06:17:12 |
| | line5 | 29-Apr-97 06:17:13 | 29-Apr-97 08:23:24 |
| | line4_5 | 29-Apr-97 08:23:25 | 29-Apr-97 08:51:37 |
| | line4 | 29-Apr-97 08:51:38 | 29-Apr-97 10:51:48 |
| | line3_4 | 29-Apr-97 10:51:49 | 29-Apr-97 11:21:16 |
| | line3 | 29-Apr-97 11:21:17 | 29-Apr-97 13:27:57 |
| | line2_3 | 29-Apr-97 13:27:58 | 29-Apr-97 13:55:47 |
| | line2 | 29-Apr-97 13:55:48 | 29-Apr-97 16:06:58 |
| | line1_2 | 29-Apr-97 16:06:59 | 29-Apr-97 16:36:19 |
| | line1 | 29-Apr-97 16:36:20 | 29-Apr-97 18:40:47 |
| | sb3_sb4 | 29-Apr-97 18:40:48 | 29-Apr-97 20:54:07 |
| **Small Box 4** | line6 | 29-Apr-97 20:54:08 | 29-Apr-97 22:57:04 |
| | line5_6 | 29-Apr-97 22:57:05 | 29-Apr-97 23:28:05 |
| | line5 | 29-Apr-97 23:28:06 | 30-Apr-97 00:55:17 |
| **Small Box 5** | lineE | 02-May-97 12:38:20 | 02-May-97 17:34:53 |
| | lineE_6 | 02-May-97 17:34:54 | 02-May-97 18:05:51 |
| | line6 | 02-May-97 18:05:52 | 02-May-97 20:17:31 |
| | line5 | 02-May-97 20:55:32 | 02-May-97 22:46:31 |
| | line4_5 | 02-May-97 22:46:32 | 02-May-97 23:18:52 |
| | line4 | 02-May-97 23:18:53 | 03-May-97 01:13:32 |
| | line3_4 | 03-May-97 01:13:33 | 03-May-97 01:45:46 |
| | line3 | 03-May-97 01:45:47 | 03-May-97 04:08:59 |
| | line2_3 | 03-May-97 04:09:00 | 03-May-97 04:43:35 |
| | line2 | 03-May-97 04:43:36 | 03-May-97 06:47:04 |
| | line1_2 | 03-May-97 06:47:05 | 03-May-97 07:17:57 |
| | line1 | 03-May-97 07:17:58 | 03-May-97 09:23:40 |
| | sb5_sb6 | 03-May-97 09:23:41 | 03-May-97 11:45:42 |

E9704 Section Times (continued)

| | section name | start time | stop time |
|---|---|---|---|
| **Small Box 6** | line6 | 03-May-97 11:45:43 | 03-May-97 13:50:16 |
| | line5_6 | 03-May-97 13:50:17 | 03-May-97 14:20:46 |
| | line5 | 03-May-97 14:20:47 | 03-May-97 16:26:08 |
| | line4_5 | 03-May-97 16:26:09 | 03-May-97 16:53:30 |
| | line4 | 03-May-97 16:53:31 | 03-May-97 19:08:28 |
| | line3_4 | 03-May-97 19:08:29 | 03-May-97 19:41:59 |
| | line3 | 03-May-97 19:42:00 | 03-May-97 21:35:08 |
| | line2_3 | 03-May-97 21:35:09 | 03-May-97 22:06:51 |
| | line2 | 03-May-97 22:06:52 | 04-May-97 00:49:17 |
| | line1_2 | 04-May-97 00:49:18 | 04-May-97 01:23:13 |
| | line1 | 04-May-97 01:23:14 | 04-May-97 02:09:45 |
| **Big Box 1** | lineA | 04-May-97 12:36:20 | 04-May-97 19:04:37 |
| | lineA_B | 04-May-97 19:04:38 | 04-May-97 20:04:36 |
| | lineB | 04-May-97 20:04:37 | 05-May-97 01:42:15 |
| | lineB_C | 05-May-97 01:42:16 | 05-May-97 02:43:33 |
| | lineC | 05-May-97 02:43:34 | 05-May-97 08:16:20 |
| | lineC_D | 05-May-97 08:16:21 | 05-May-97 09:16:59 |
| | lineD | 05-May-97 09:17:00 | 05-May-97 16:04:09 |
| | lineD_E | 05-May-97 16:04:10 | 05-May-97 17:06:16 |
| | lineE1 | 05-May-97 17:06:17 | 05-May-97 20:48:29 |
| | lineE | 05-May-97 17:06:17 | 06-May-97 00:32:47 |
| | lineE2 | 05-May-97 21:49:09 | 06-May-97 00:32:47 |
| | lineE_F | 06-May-97 00:32:48 | 06-May-97 01:24:53 |
| | lineF | 06-May-97 03:37:07 | 06-May-97 10:15:19 |
| | lineF_G | 06-May-97 10:15:20 | 06-May-97 11:10:33 |
| | lineG | 06-May-97 11:10:34 | 06-May-97 17:32:19 |
| | bb1_sb7a | 06-May-97 17:32:20 | 06-May-97 19:58:08 |
| | bb1_sb7b | 06-May-97 19:58:09 | 06-May-97 20:33:16 |
| **Small Box 7** | line6 | 06-May-97 20:33:17 | 06-May-97 22:38:39 |
| | line5_6 | 06-May-97 22:38:40 | 06-May-97 23:09:59 |
| | line5 | 06-May-97 23:10:00 | 07-May-97 01:09:38 |
| | line4_5 | 07-May-97 01:09:39 | 07-May-97 01:39:37 |
| | line4 | 07-May-97 01:39:38 | 07-May-97 03:44:06 |
| | line3_4 | 07-May-97 03:44:07 | 07-May-97 04:16:01 |
| | line3a | 07-May-97 04:16:02 | 07-May-97 06:37:09 |
| | line3b | 07-May-97 06:37:10 | 07-May-97 08:40:52 |
| | line2_3 | 07-May-97 08:40:53 | 07-May-97 09:08:56 |
| | line2 | 07-May-97 09:08:57 | 07-May-97 11:06:37 |
| | line1_2 | 07-May-97 11:06:38 | 07-May-97 11:37:04 |
| | line1 | 07-May-97 11:37:05 | 07-May-97 13:50:55 |

E9704 Section Times (continued)

| | section name | start time | stop time |
|---|---|---|---|
| **Small Box 8** | line1a | 07-May-97 13:50:56 | 07-May-97 15:07:21 |
| | bf1lineWE | 07-May-97 15:07:22 | 07-May-97 17:30:08 |
| | line6a | 07-May-97 17:30:09 | 07-May-97 18:16:28 |
| | line6b | 07-May-97 18:16:29 | 07-May-97 19:33:38 |
| | line6 | 07-May-97 18:16:29 | 08-May-97 07:01:54 |
| | line6c | 08-May-97 05:39:23 | 08-May-97 07:01:54 |
| | line5_6 | 08-May-97 07:01:55 | 08-May-97 07:33:50 |
| | line5 | 08-May-97 07:33:51 | 08-May-97 09:32:51 |
| | line4_5 | 08-May-97 09:32:52 | 08-May-97 09:57:29 |
| | line4 | 08-May-97 09:57:30 | 08-May-97 11:57:19 |
| | line3_4 | 08-May-97 11:57:20 | 08-May-97 12:26:30 |
| | line3a | 08-May-97 12:26:31 | 08-May-97 13:04:50 |
| | line3 | 08-May-97 18:57:28 | 08-May-97 20:48:19 |
| | line2_3 | 08-May-97 20:48:20 | 08-May-97 21:16:07 |
| | line2 | 08-May-97 21:16:08 | 08-May-97 23:14:50 |
| | line1_2 | 08-May-97 23:14:51 | 08-May-97 23:41:51 |
| | line1 | 08-May-97 23:41:52 | 09-May-97 01:57:21 |
| **Small Box 9** | line1a | 09-May-97 01:57:22 | 09-May-97 03:11:53 |
| | bf2lineWE | 09-May-97 03:11:54 | 09-May-97 05:34:20 |
| | line6a | 09-May-97 05:34:21 | 09-May-97 06:01:59 |
| | line6 | 09-May-97 06:02:00 | 09-May-97 08:14:59 |
| | line5_6 | 09-May-97 08:15:00 | 09-May-97 08:45:55 |
| | line5 | 09-May-97 09:08:07 | 09-May-97 11:09:21 |
| | line4_5 | 09-May-97 11:09:22 | 09-May-97 11:35:03 |
| | line4 | 09-May-97 11:35:04 | 09-May-97 13:33:29 |
| | line3_4 | 09-May-97 13:33:30 | 09-May-97 14:00:01 |
| | line3 | 09-May-97 14:00:02 | 09-May-97 16:16:43 |
| | line2_3 | 09-May-97 16:16:44 | 09-May-97 16:44:59 |
| | line2 | 09-May-97 16:45:00 | 09-May-97 18:32:48 |
| | line1_2 | 09-May-97 18:32:49 | 09-May-97 19:03:17 |
| | line1 | 09-May-97 19:03:18 | 09-May-97 21:11:56 |
| **Small Box 10** | line1a | 09-May-97 21:41:01 | 09-May-97 22:43:54 |
| | bf3lineWE | 09-May-97 22:43:55 | 10-May-97 01:01:16 |
| | line6a | 10-May-97 01:13:01 | 10-May-97 01:54:14 |
| | line6 | 10-May-97 01:54:15 | 10-May-97 04:03:42 |
| | line5_6 | 10-May-97 04:03:43 | 10-May-97 04:36:24 |
| | line5 | 10-May-97 04:36:25 | 10-May-97 06:45:54 |
| | line4_5 | 10-May-97 06:45:55 | 10-May-97 07:13:24 |
| | line4 | 10-May-97 07:13:25 | 10-May-97 09:23:11 |
| | line3_4 | 10-May-97 09:23:12 | 10-May-97 09:48:14 |
| | line3 | 10-May-97 09:48:15 | 10-May-97 11:49:59 |
| | line2_3 | 10-May-97 11:50:00 | 10-May-97 12:17:32 |
| | line2 | 10-May-97 12:17:33 | 10-May-97 14:10:31 |
| | line1_2 | 10-May-97 14:10:32 | 10-May-97 14:38:22 |
| | line1 | 10-May-97 14:38:23 | 10-May-97 17:05:23 |

E9704 Section Times (continued)

| | section name | start time | stop time |
|---|---|---|---|
| **Small Box 11** | line1 | 11-May-97 11:22:01 | 11-May-97 13:30:36 |
| | line1_2 | 11-May-97 13:30:37 | 11-May-97 13:58:56 |
| | line2 | 11-May-97 13:58:57 | 11-May-97 16:02:36 |
| | line2_3 | 11-May-97 16:02:37 | 11-May-97 16:28:16 |
| | line3 | 11-May-97 16:28:17 | 11-May-97 18:32:42 |
| | line3_4 | 11-May-97 18:32:43 | 11-May-97 18:57:40 |
| | line4 | 11-May-97 18:57:41 | 11-May-97 20:58:52 |
| | line4_5 | 11-May-97 20:58:53 | 11-May-97 21:23:36 |
| | line5 | 11-May-97 21:23:37 | 11-May-97 23:28:16 |
| | line5_6 | 11-May-97 23:28:17 | 11-May-97 23:58:16 |
| | line6 | 11-May-97 23:58:17 | 12-May-97 02:08:30 |
| **Small Box 12** | line5_6 | 12-May-97 02:08:31 | 12-May-97 02:42:59 |
| | line5 | 12-May-97 02:43:00 | 12-May-97 04:44:15 |
| | line4_5 | 12-May-97 04:44:16 | 12-May-97 05:16:47 |
| | line4 | 12-May-97 05:16:48 | 12-May-97 07:23:49 |
| | line3_4 | 12-May-97 07:23:50 | 12-May-97 07:55:09 |
| | line3 | 12-May-97 07:55:10 | 12-May-97 10:00:55 |
| | line2_3 | 12-May-97 10:00:56 | 12-May-97 10:29:45 |
| | line2 | 12-May-97 10:29:46 | 12-May-97 12:25:17 |
| | line1_2 | 12-May-97 12:25:18 | 12-May-97 12:51:33 |
| | line1 | 12-May-97 12:51:34 | 12-May-97 14:53:06 |
| | sb12_bb2 | 12-May-97 14:53:07 | 12-May-97 15:59:34 |
| **Big Box 2** | lineC | 12-May-97 15:59:35 | 12-May-97 22:35:59 |
| | lineA_C | 12-May-97 22:36:00 | 13-May-97 00:26:26 |
| | lineA | 13-May-97 00:26:27 | 13-May-97 06:52:16 |
| | lineA_B | 13-May-97 06:52:17 | 13-May-97 07:48:21 |
| | lineB | 13-May-97 07:48:22 | 13-May-97 14:21:03 |
| | lineC_D | 13-May-97 17:57:27 | 13-May-97 18:59:24 |
| | lineD | 13-May-97 18:59:25 | 14-May-97 01:34:10 |
| | lineD_E | 14-May-97 01:34:11 | 14-May-97 02:31:03 |
| | lineE | 14-May-97 02:31:04 | 14-May-97 08:50:57 |
| | lineE_F | 14-May-97 08:50:58 | 14-May-97 09:45:29 |
| | lineF | 14-May-97 09:45:30 | 14-May-97 15:31:35 |
| | lineF_G | 14-May-97 15:31:36 | 14-May-97 16:29:04 |
| | lineG | 14-May-97 16:29:05 | 14-May-97 23:07:09 |

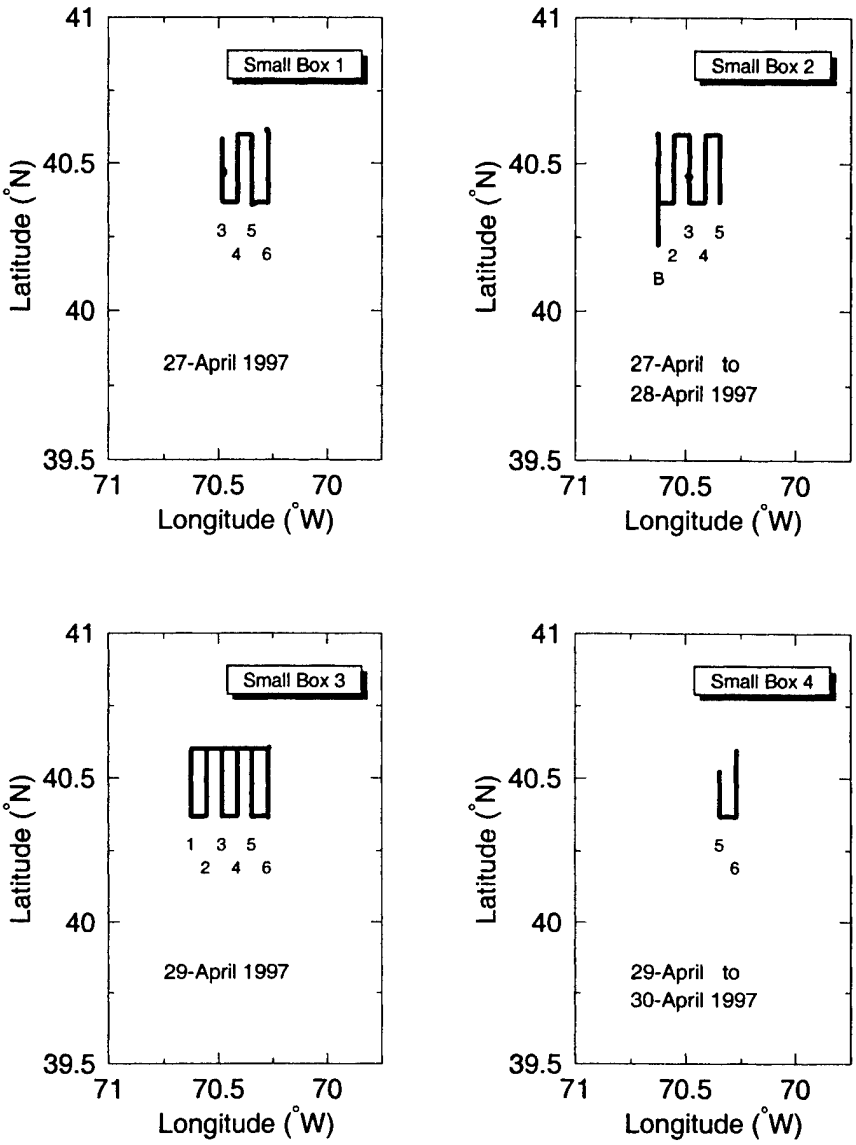



Figure 21: a: Cruise tracks during the E9704 SeaSoar surveys.

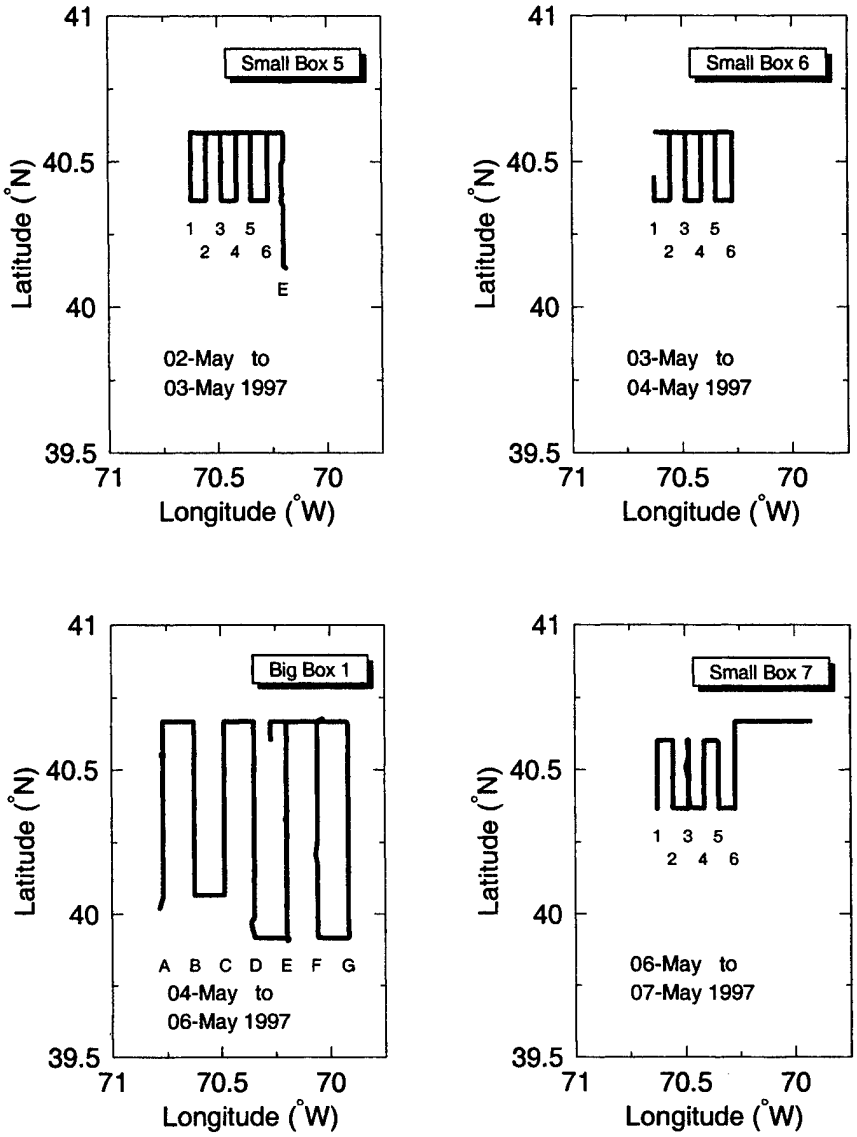



Figure 22: b: Cruise tracks during the E9704 SeaSoar surveys.

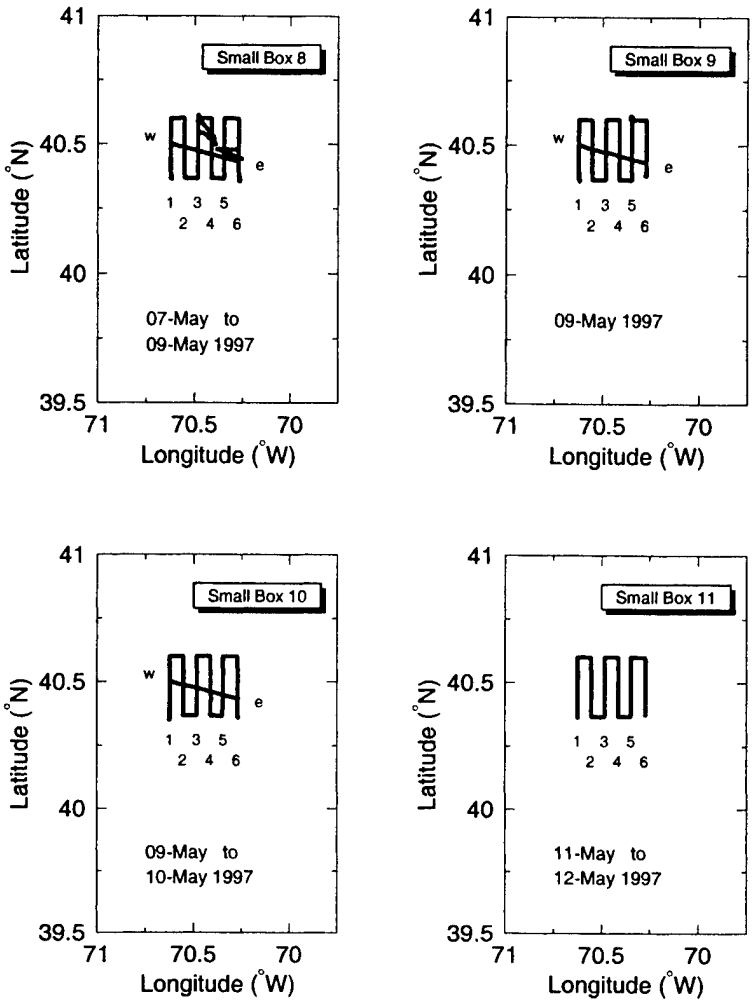



Figure 23: c: Cruise tracks during the E9704 SeaSoar surveys.

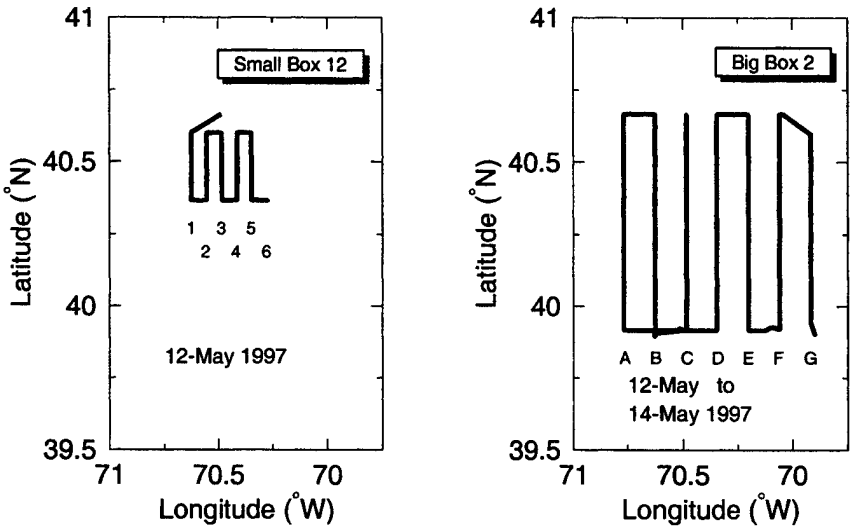
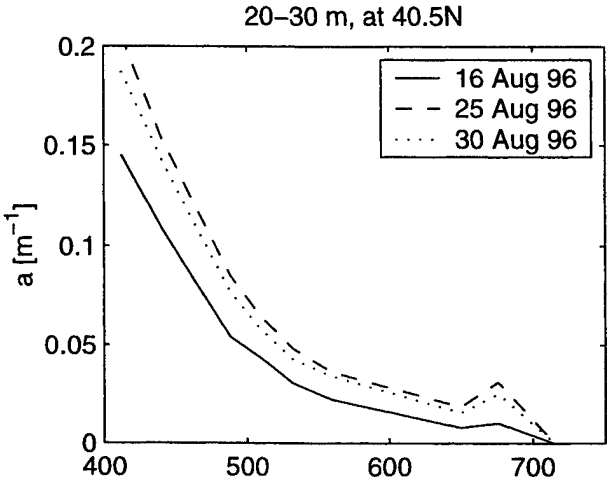
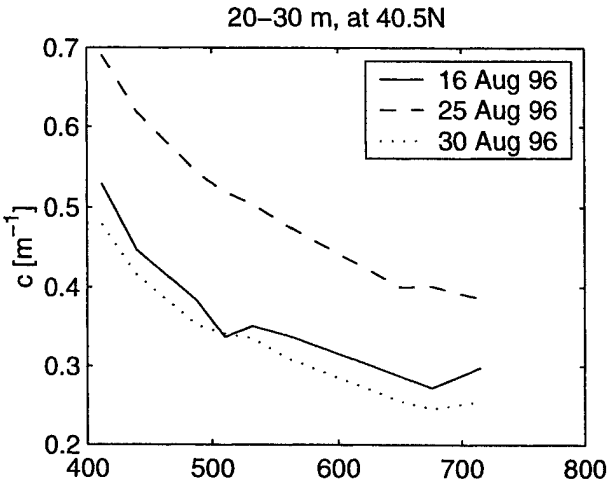
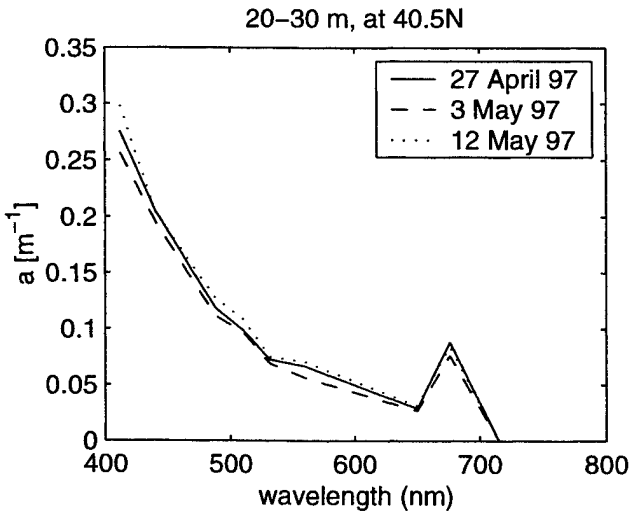


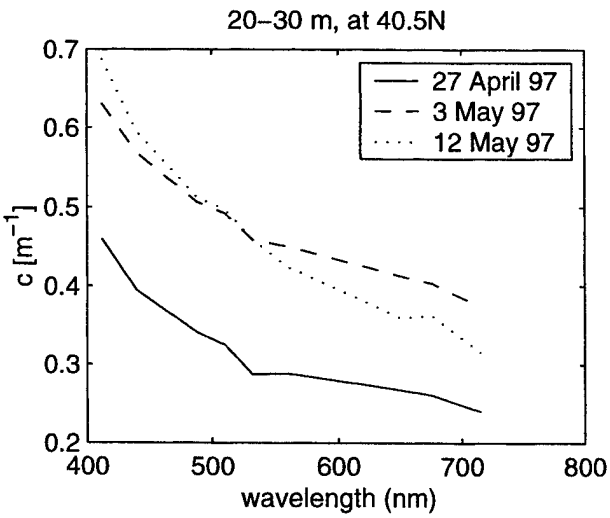

Figure 24: d: Cruise tracks during the E9704 SeaSoar surveys.

# E9608 and E9704 Absorption and Attenuation Spectra


20–30 m, at 40.5N
16 Aug 96
25 Aug 96
30 Aug 96
a [m$^{-1}$]
0.2
0.15
0.1
0.05
0
400
500
600
700


20–30 m, at 40.5N
16 Aug 96
25 Aug 96
30 Aug 96
c [m$^{-1}$]
0.7
0.6
0.5
0.4
0.3
0.2
400
500
600
700
800


20–30 m, at 40.5N
27 April 97
3 May 97
12 May 97
a [m$^{-1}$]
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
400
500
600
700
800
wavelength (nm)


20–30 m, at 40.5N
27 April 97
3 May 97
12 May 97
c [m$^{-1}$]
0.7
0.6
0.5
0.4
0.3
0.2
400
500
600
700
800
wavelength (nm)

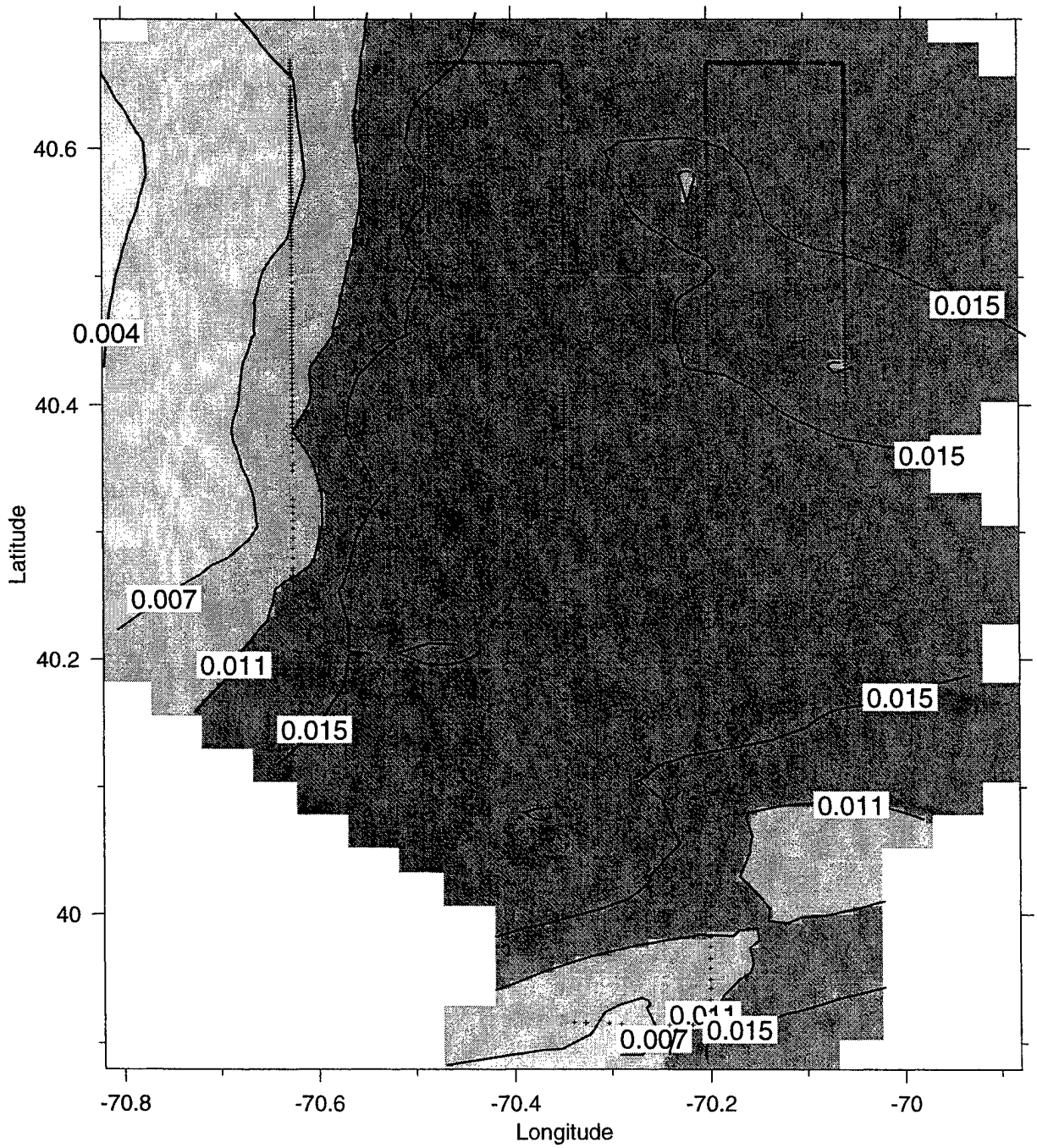
# E9608 Bigbox Maps

# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at 5 m**

a(676) $m^{-1}$

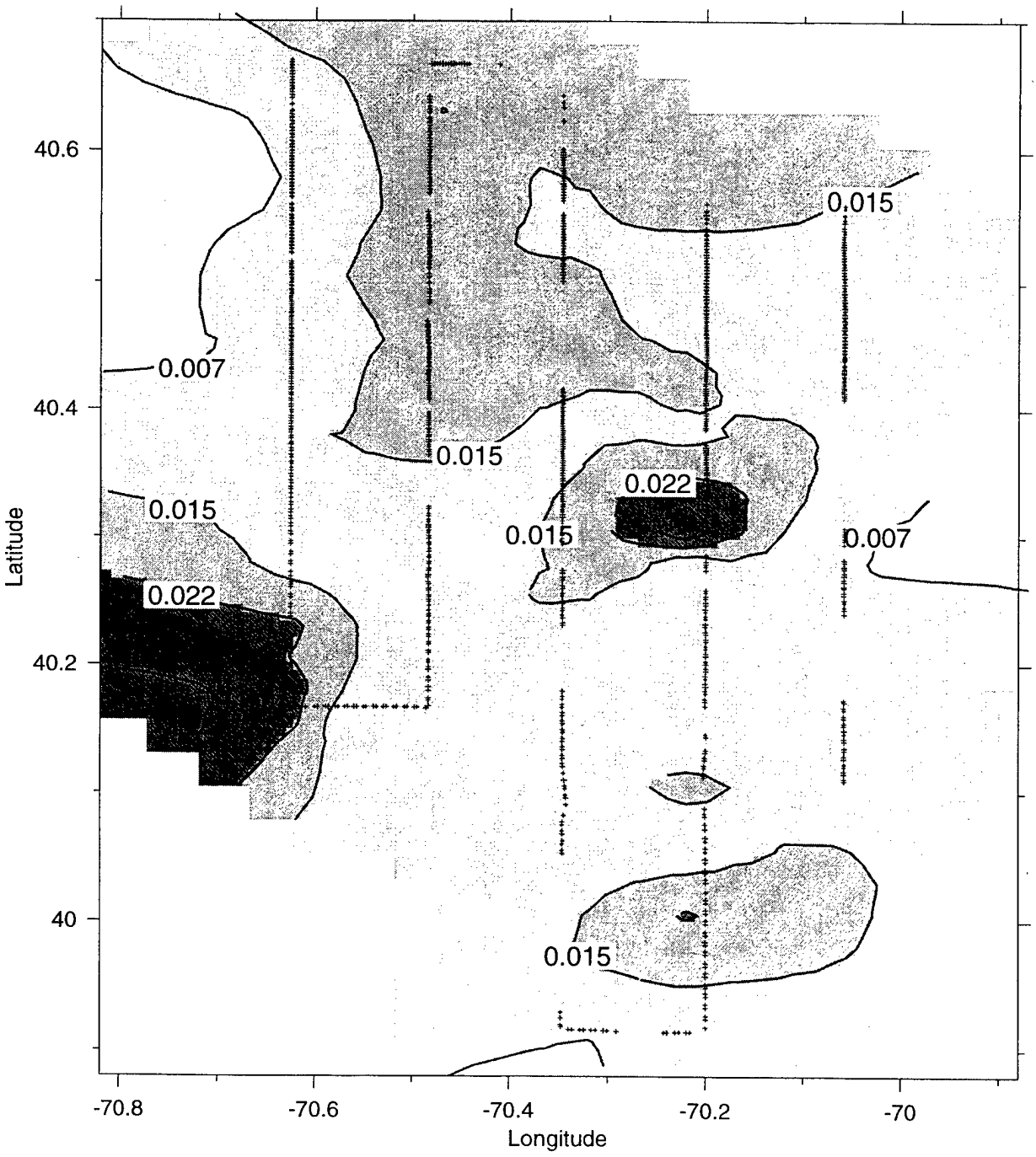


# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at 45 m**

a(676) $m^{-1}$

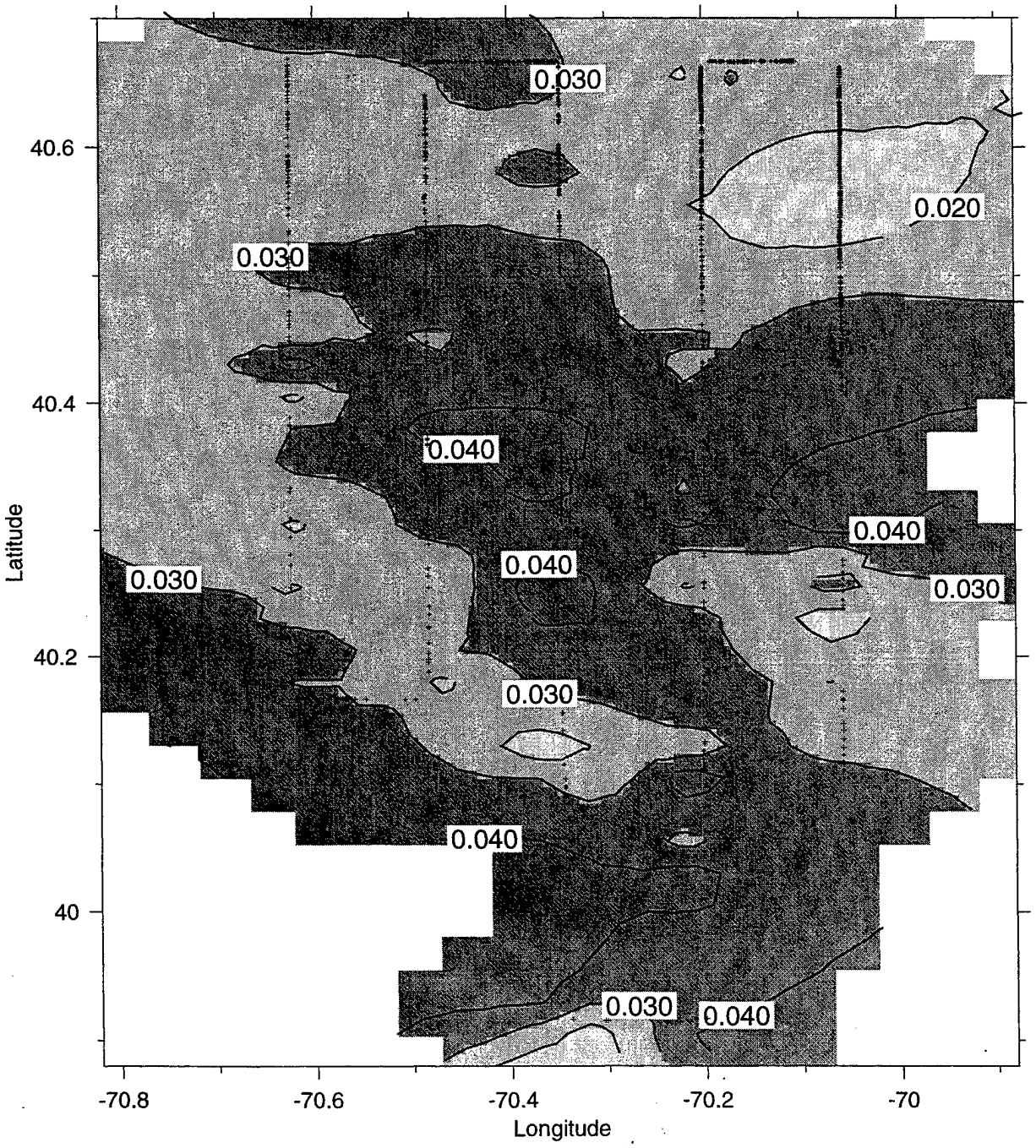


# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at $\sigma_t$ = 24.6 ± 0.025 kg/m$^3$**

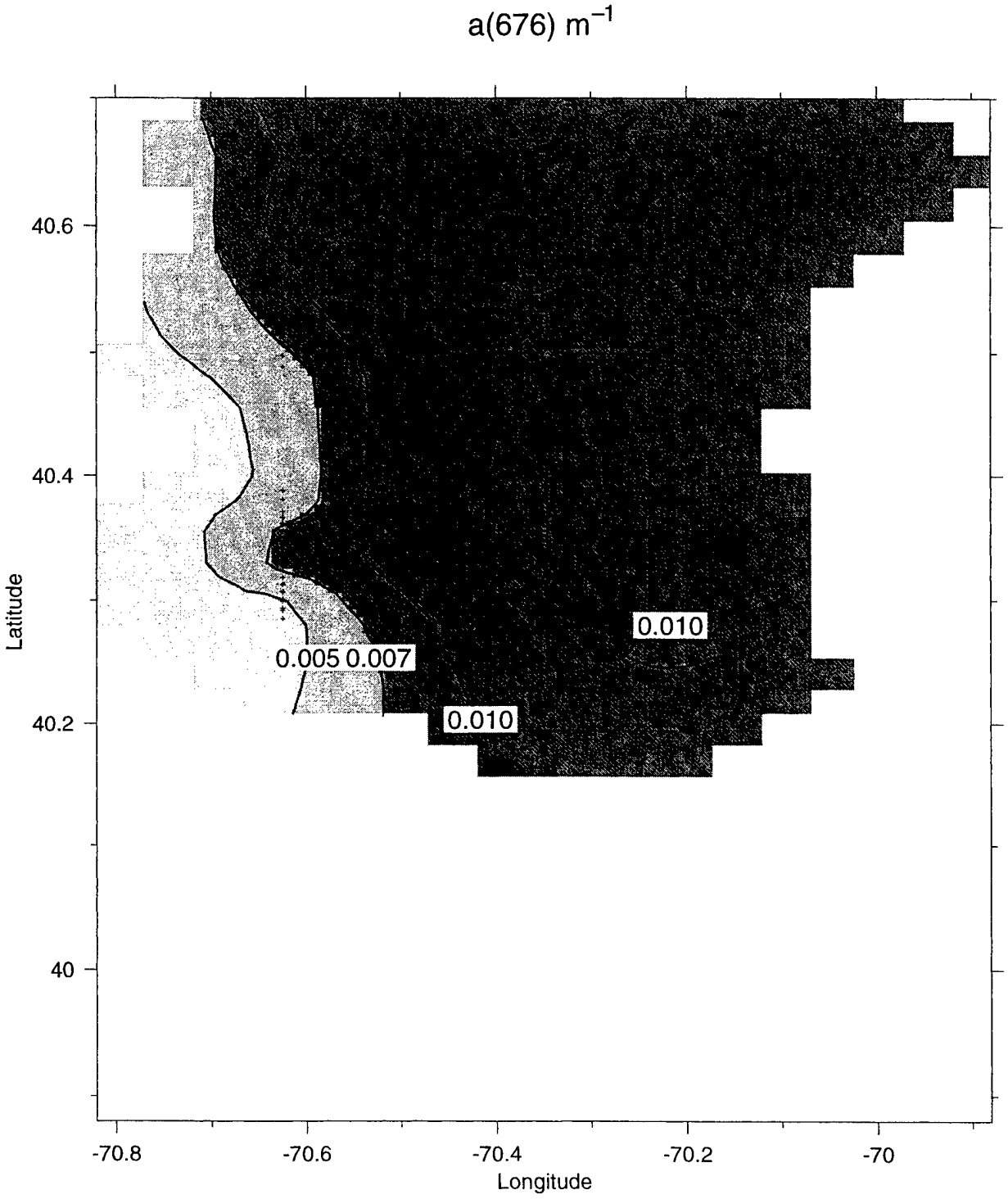
a(676) m$^{-1}$



# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at 10 m above bottom**

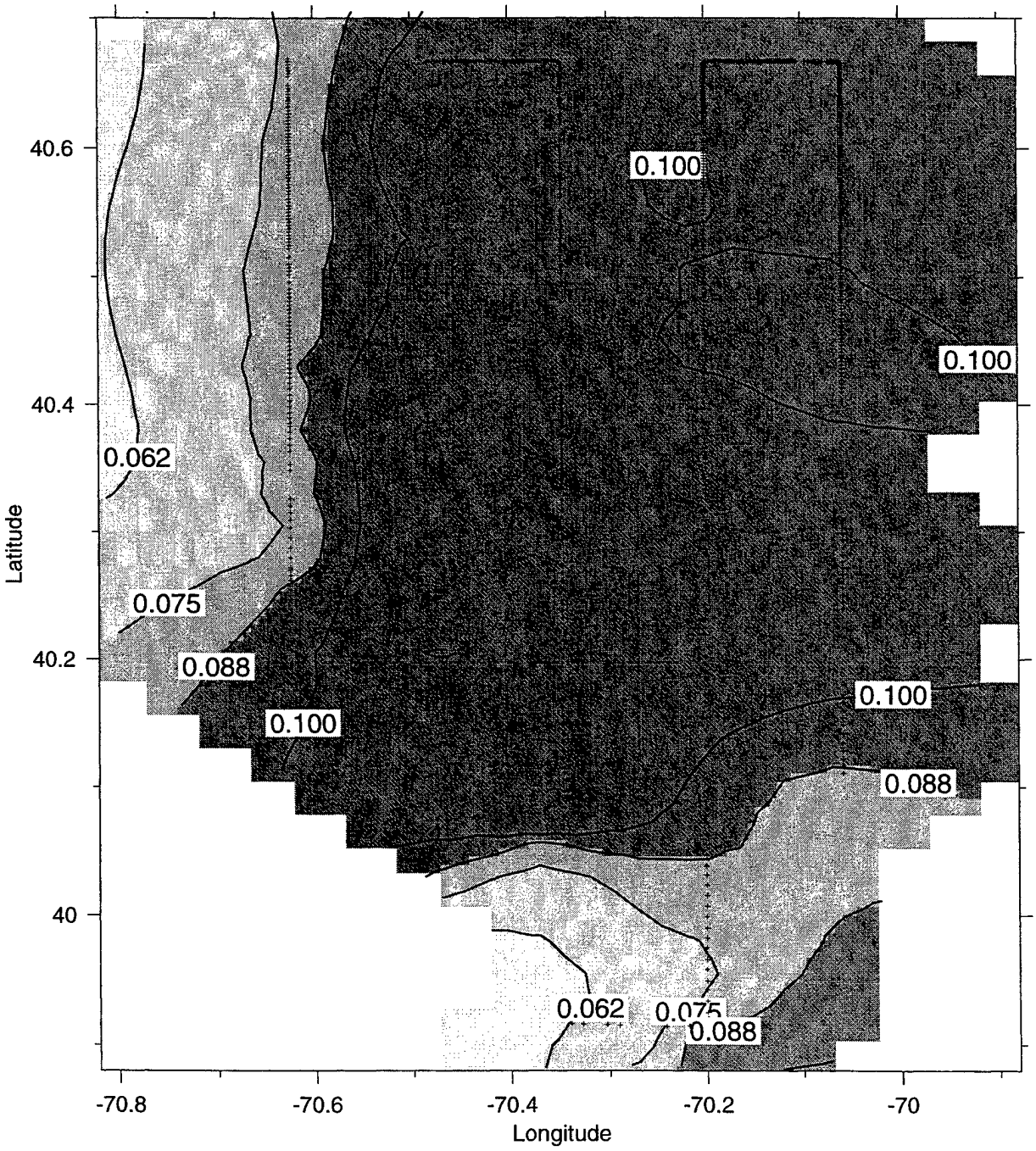


# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at 5 m**

a(440) $m^{-1}$

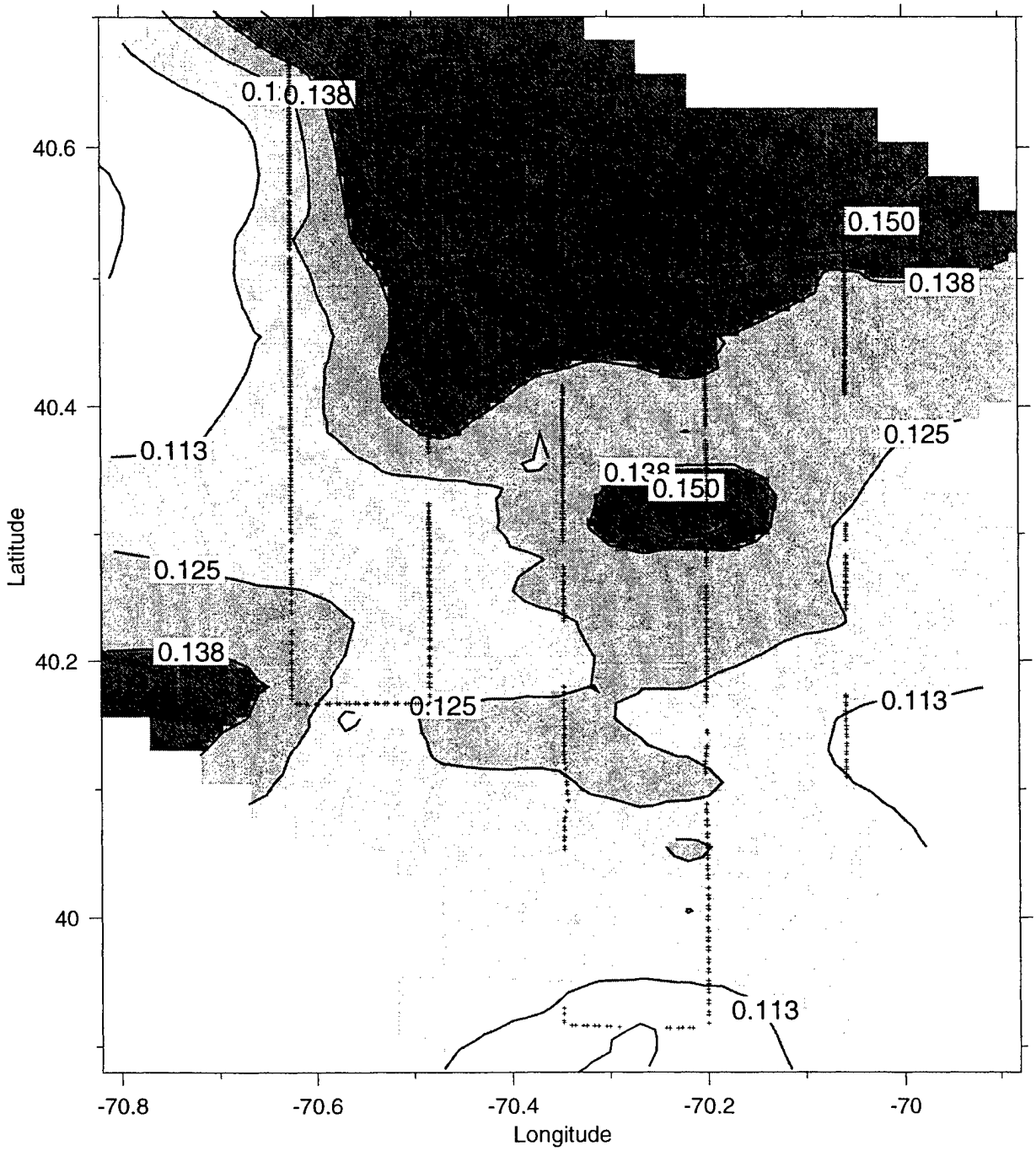


# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at 45 m**

a(440) $m^{-1}$

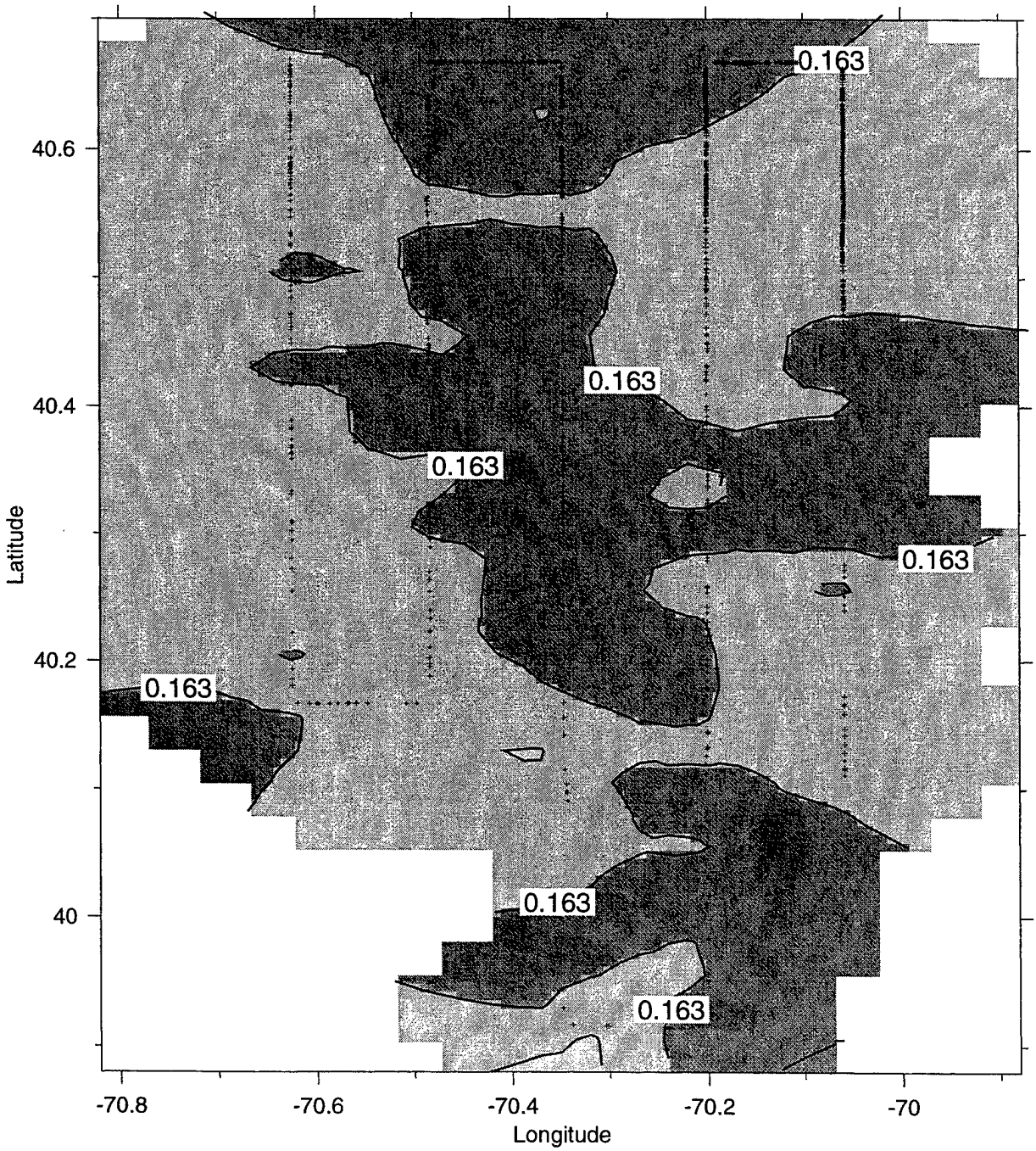


# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$**

a(440) m$^{-1}$

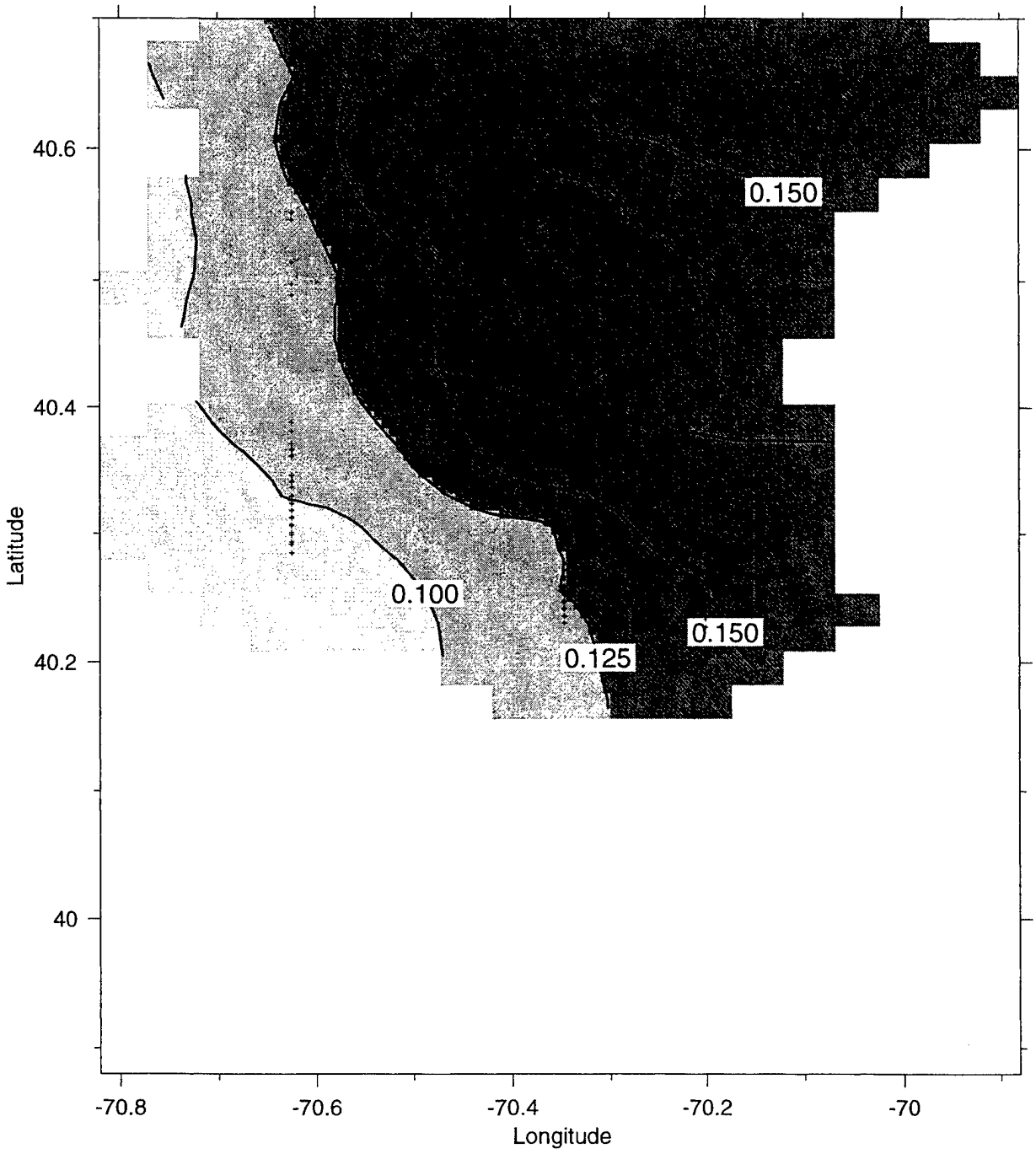


# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at 10 m above bottom**

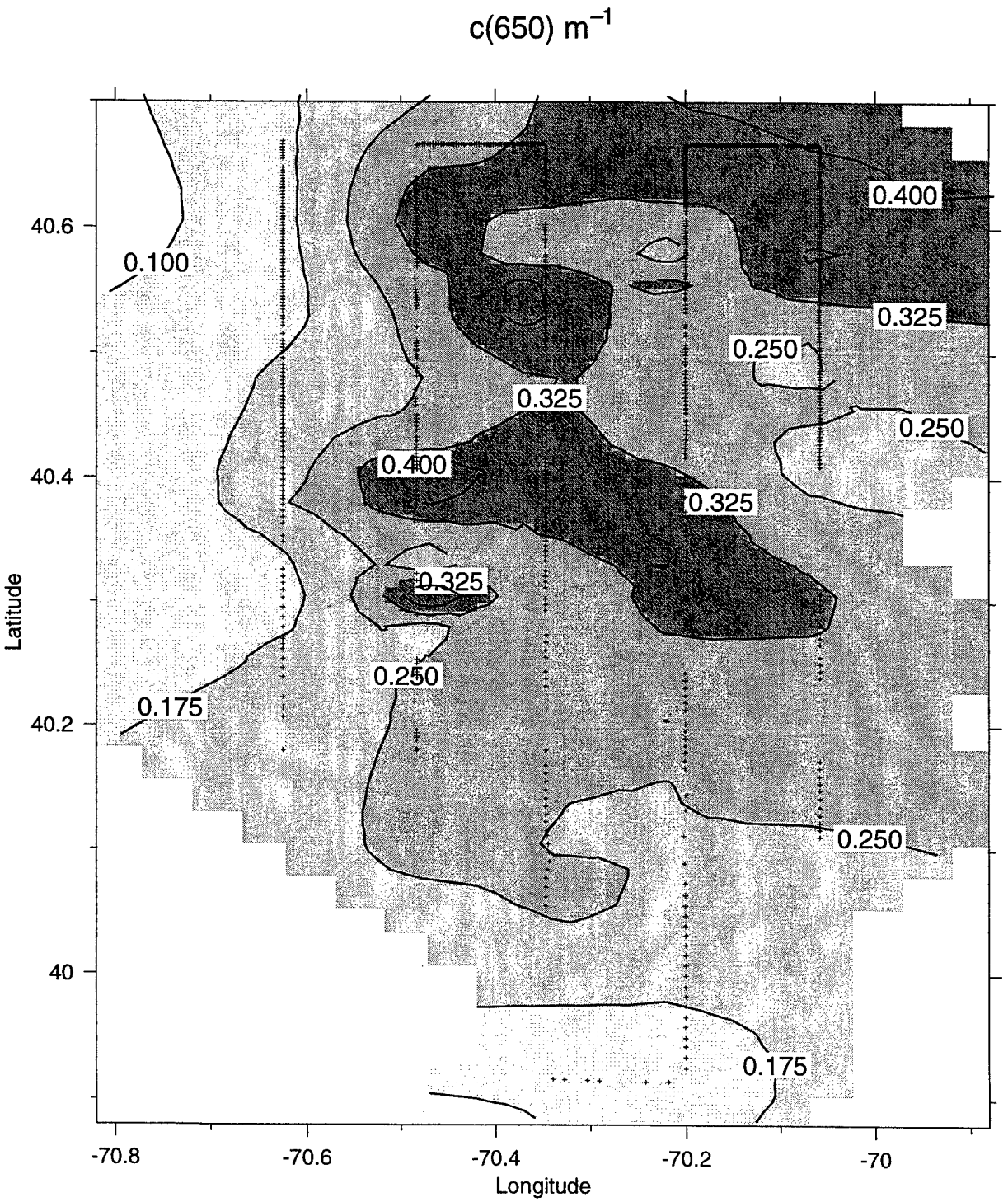
a(440) $m^{-1}$



# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at 5 m**

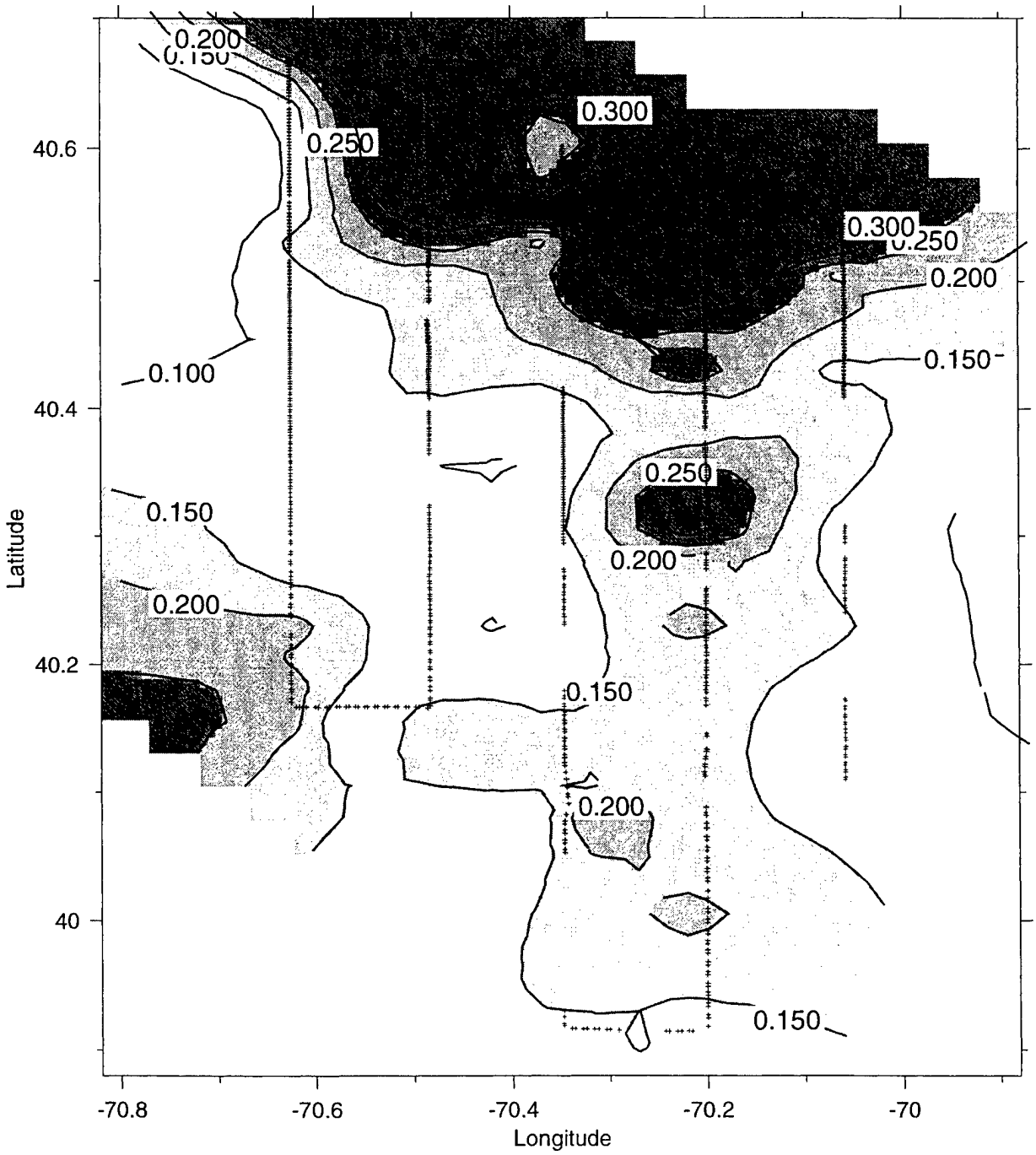


# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at 45 m**

c(650) $m^{-1}$

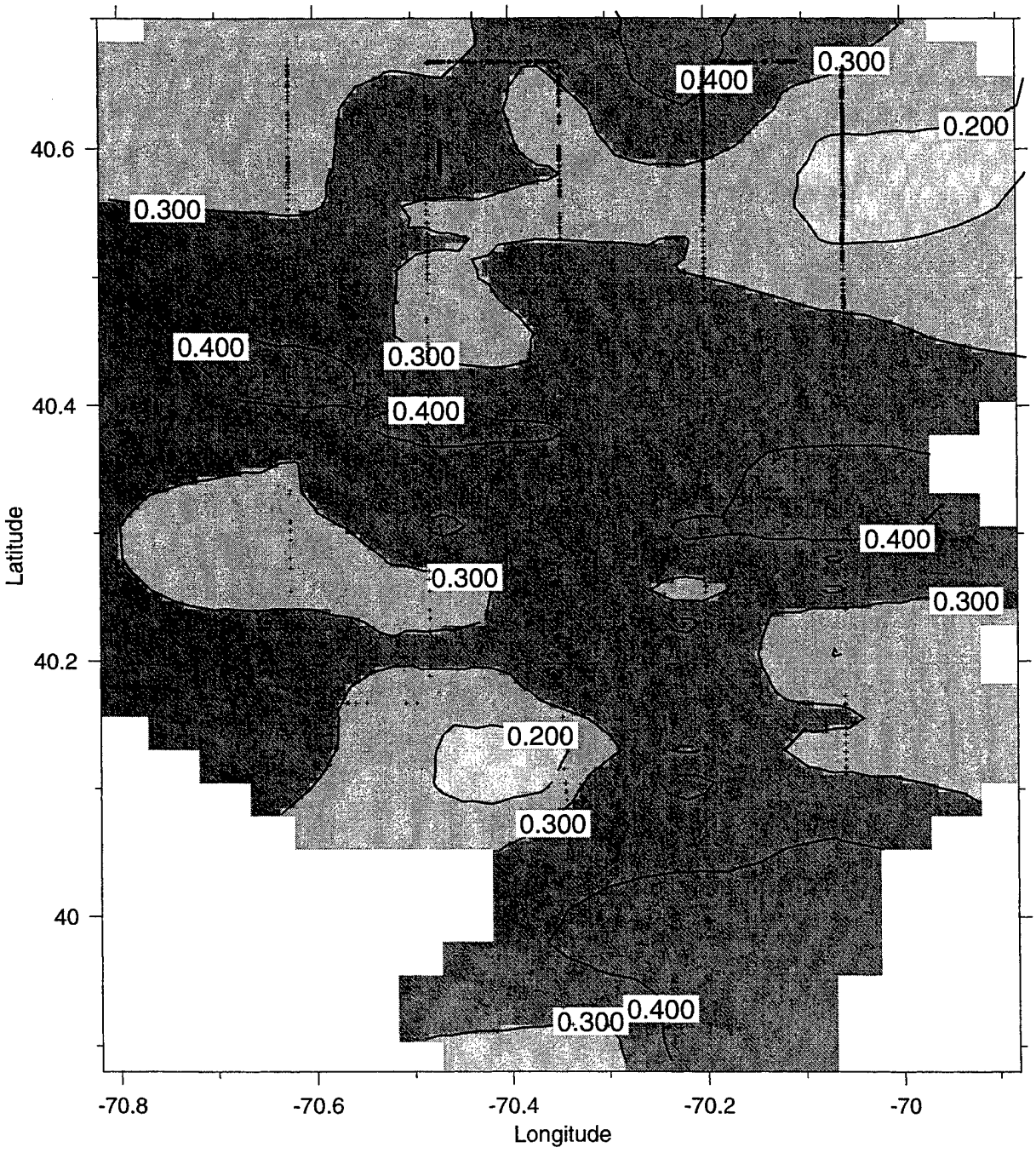


# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$**

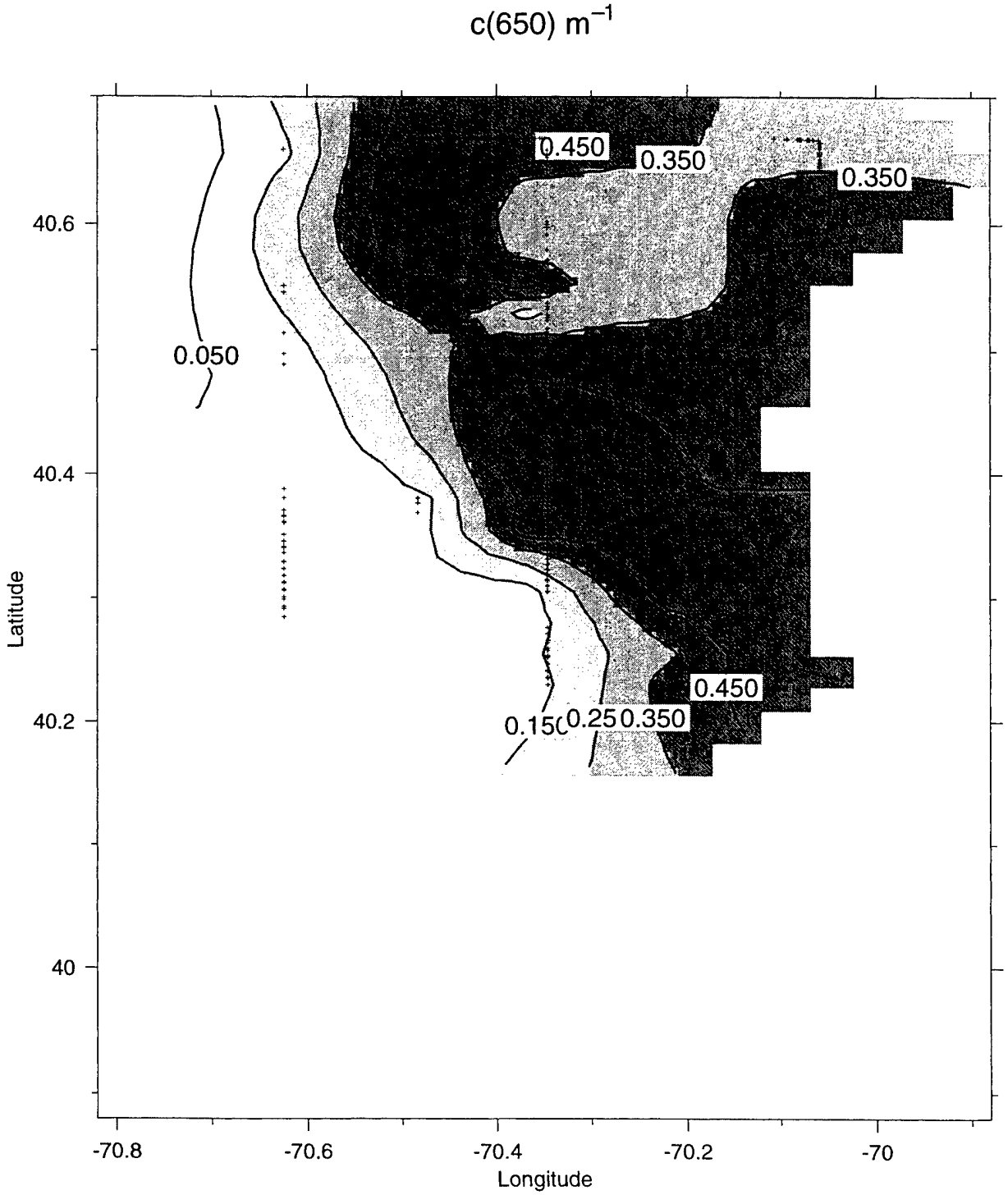
c(650) m$^{-1}$



# E9608 Bigbox 1

17-Aug-96 02:02 to 18-Aug-96 05:21

**Map view at 10 m above bottom**

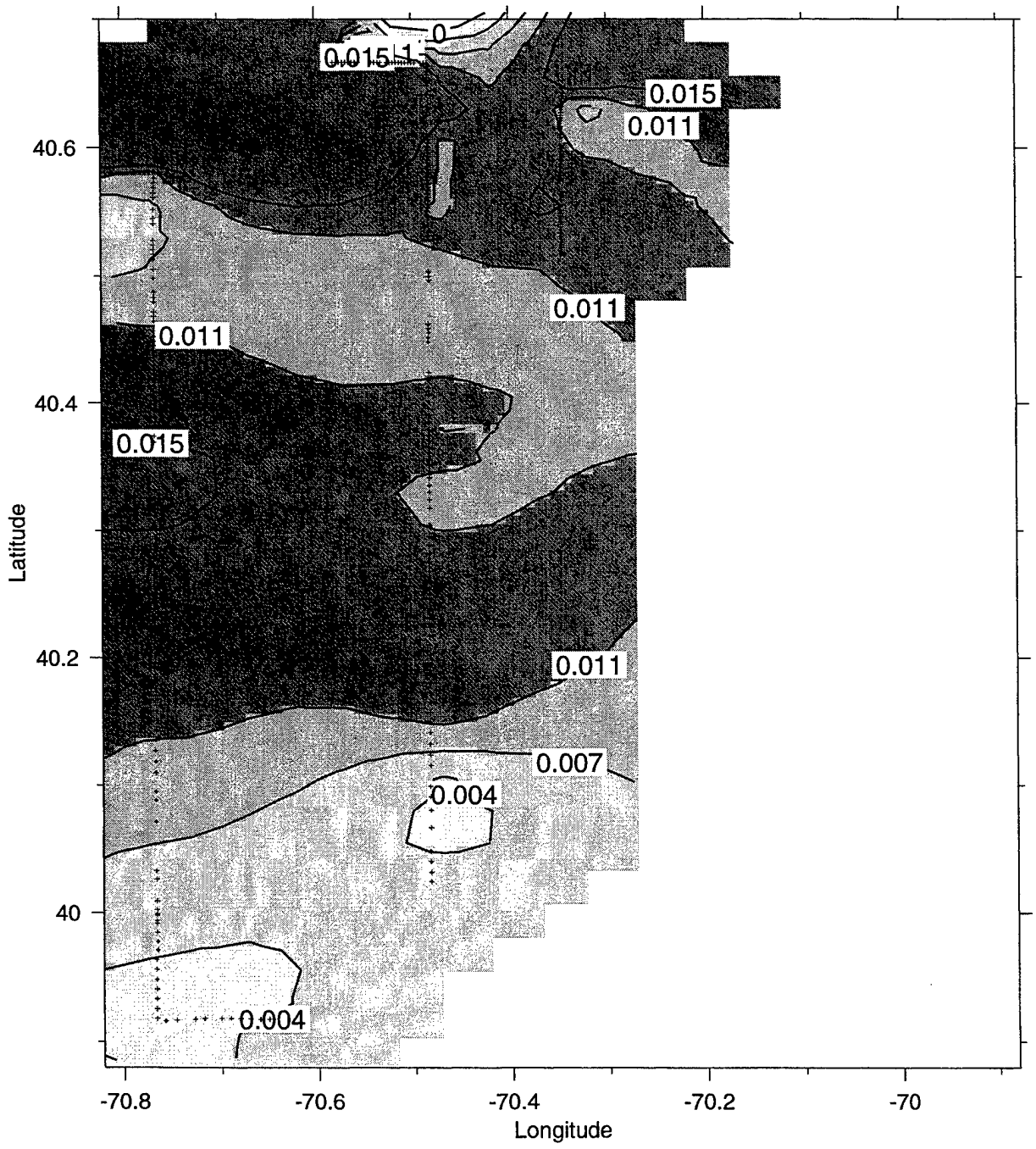


# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

**Map view at 5 m**

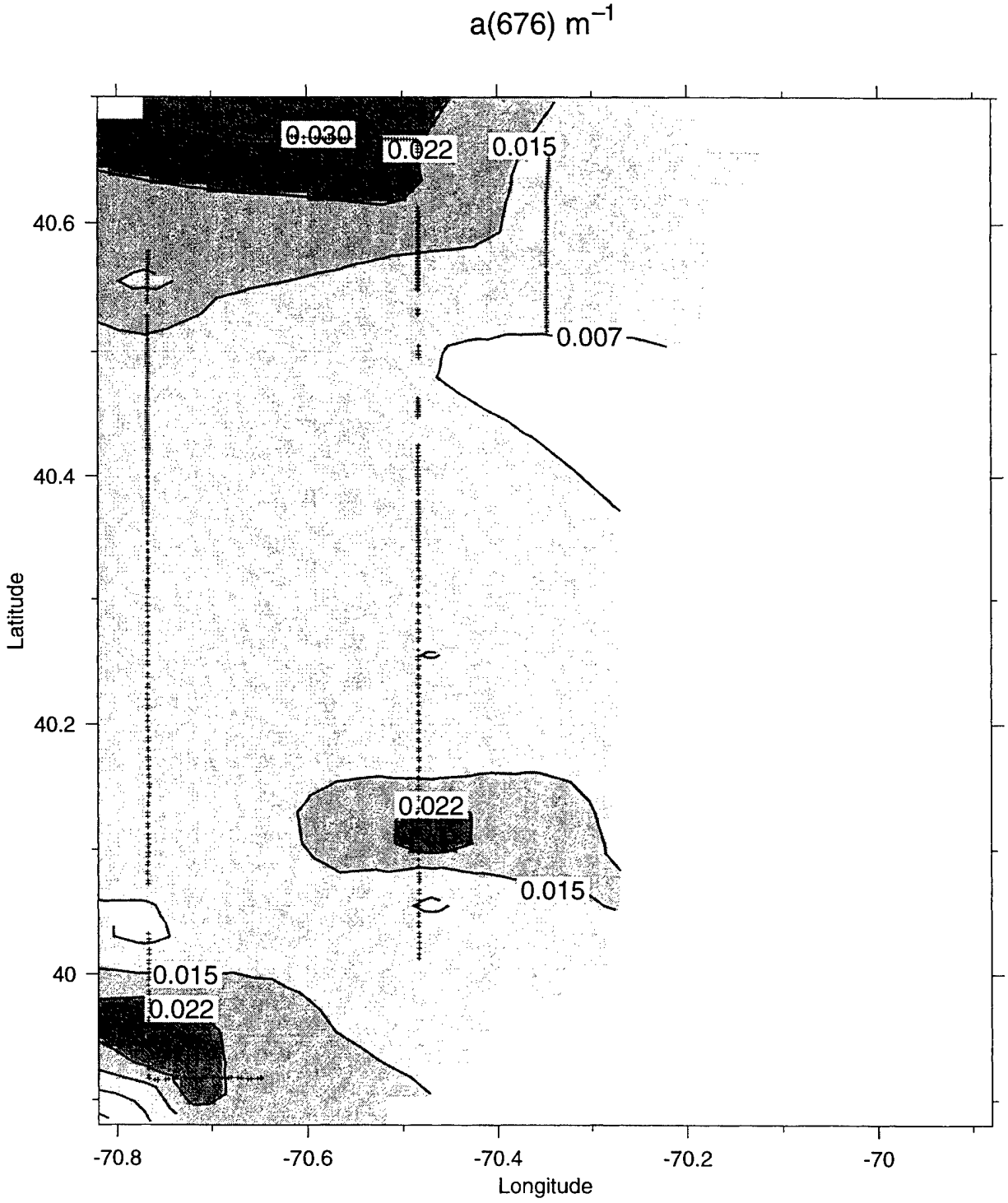
a(676) $m^{-1}$



# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

**Map view at 45 m**

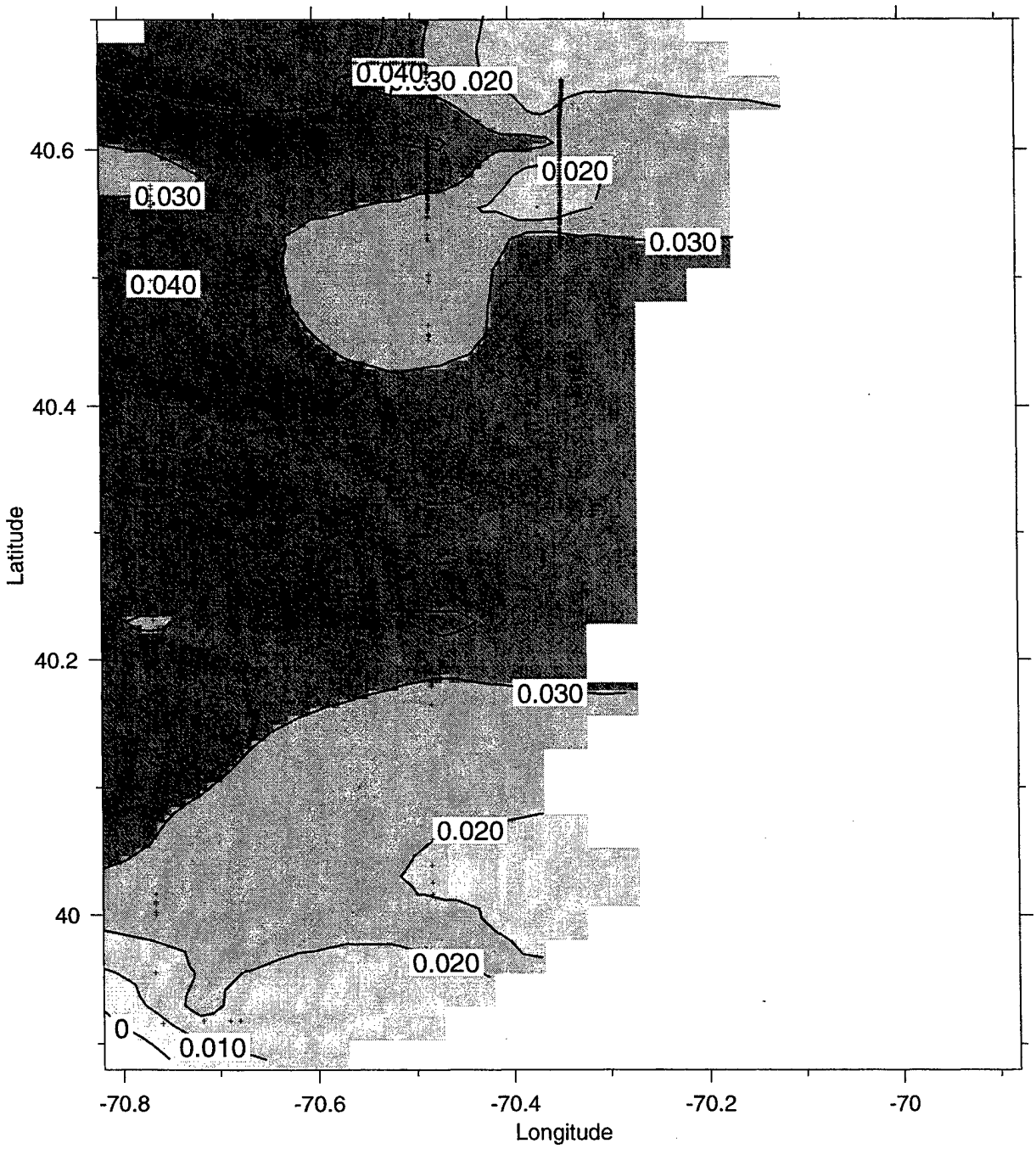


# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$**

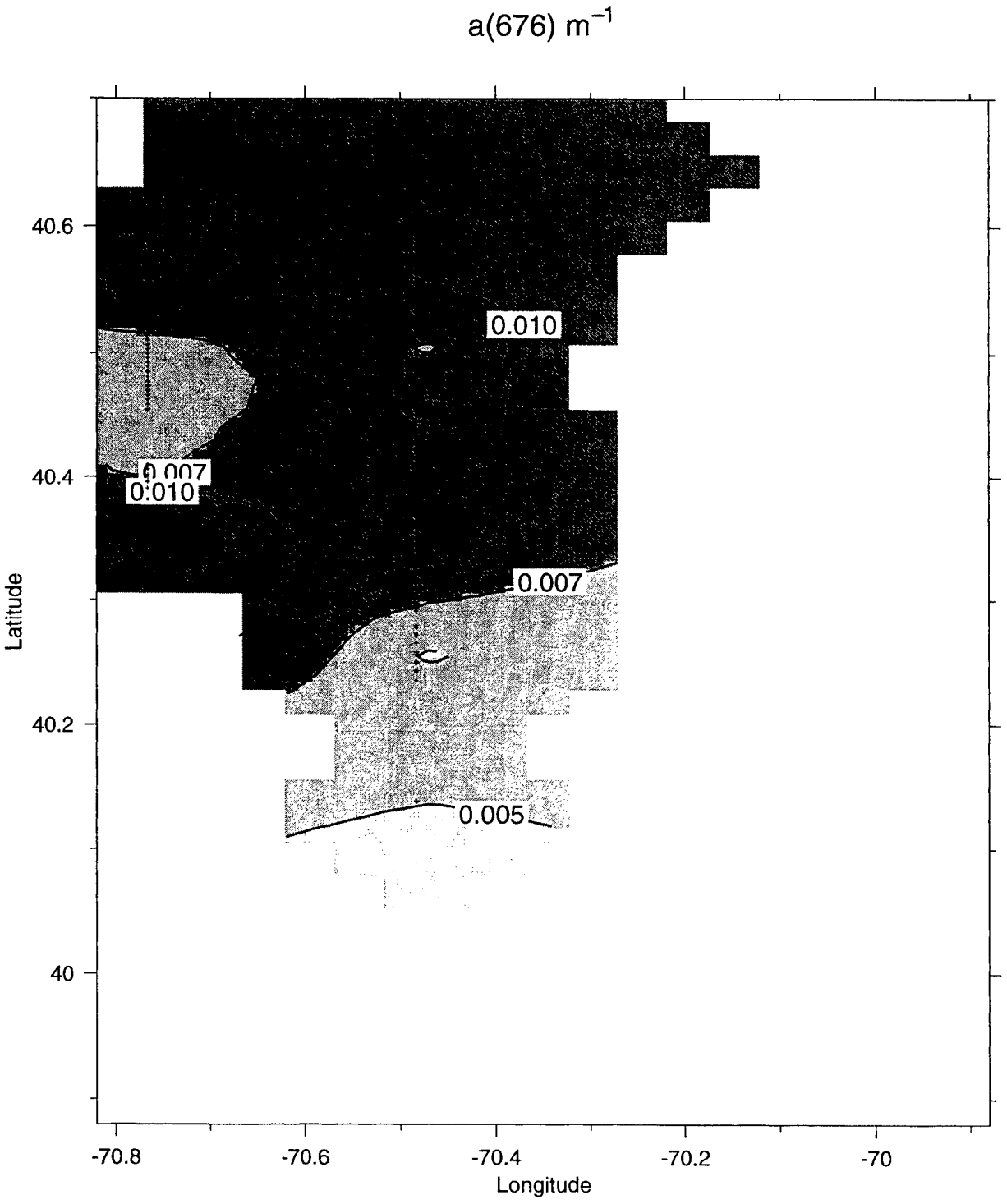
a(676) m$^{-1}$



# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

**Map view at 10 m above bottom**

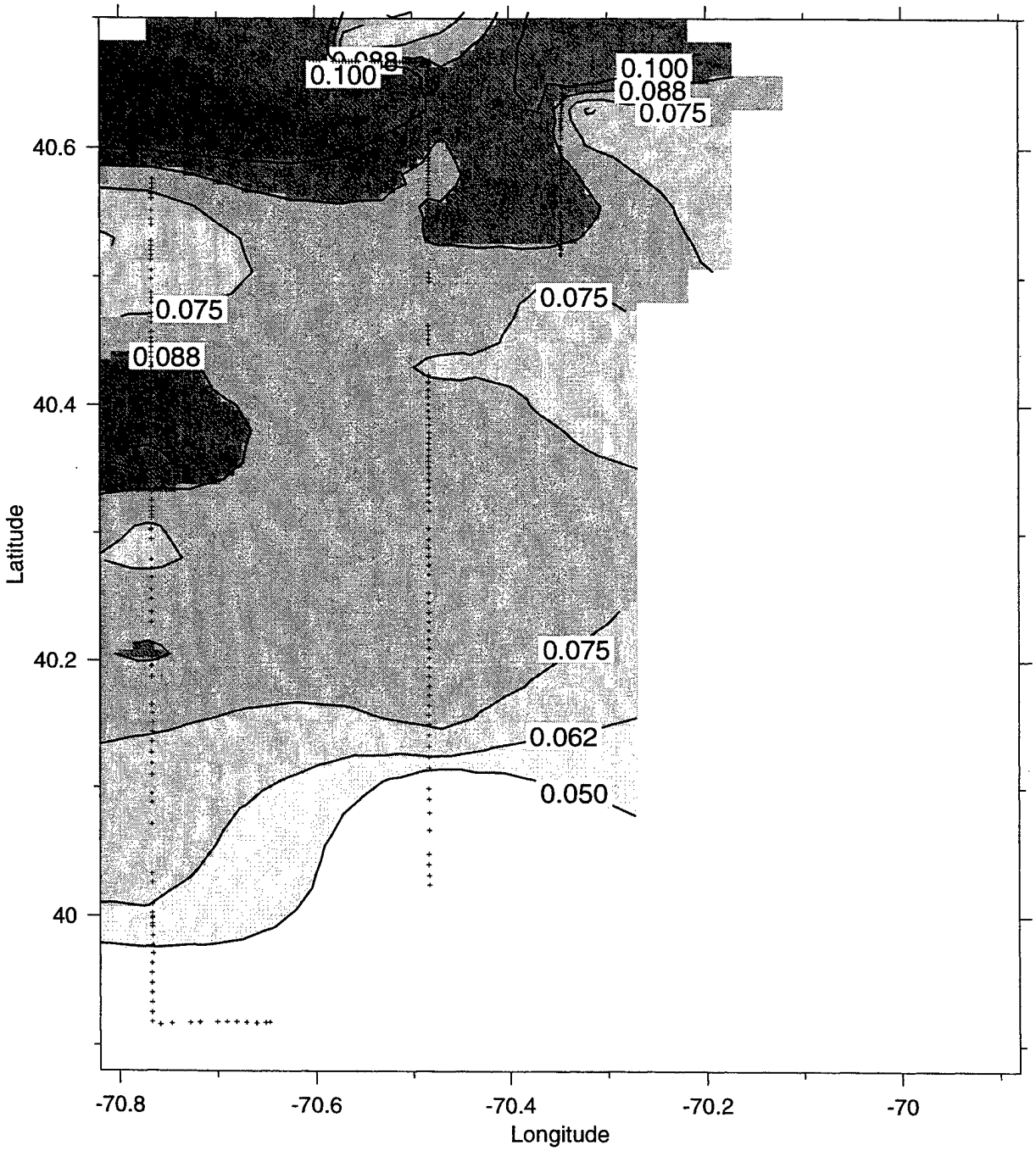


# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

**Map view at 5 m**

a(440) $m^{-1}$

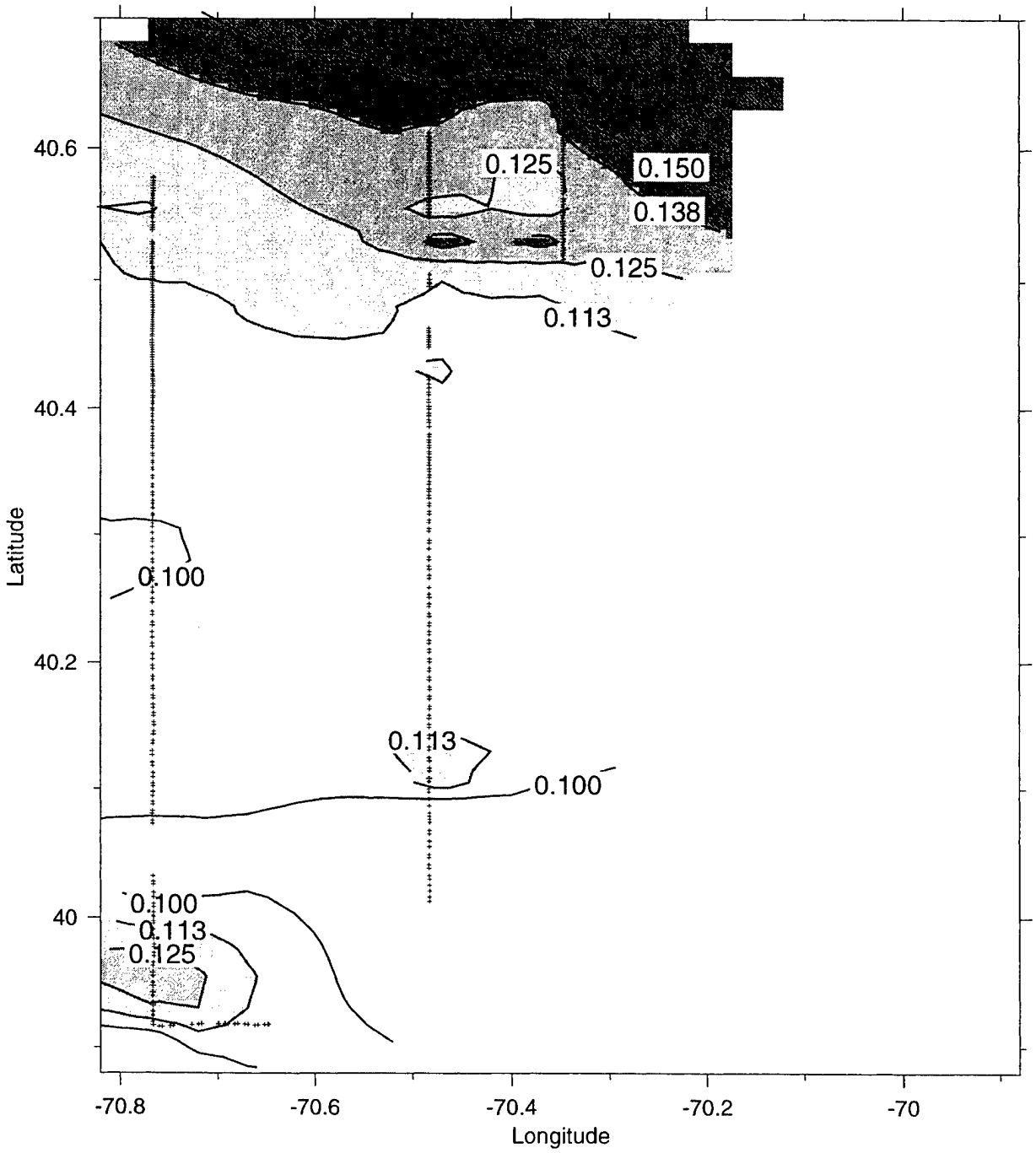


# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

**Map view at 45 m**

a(440) $m^{-1}$

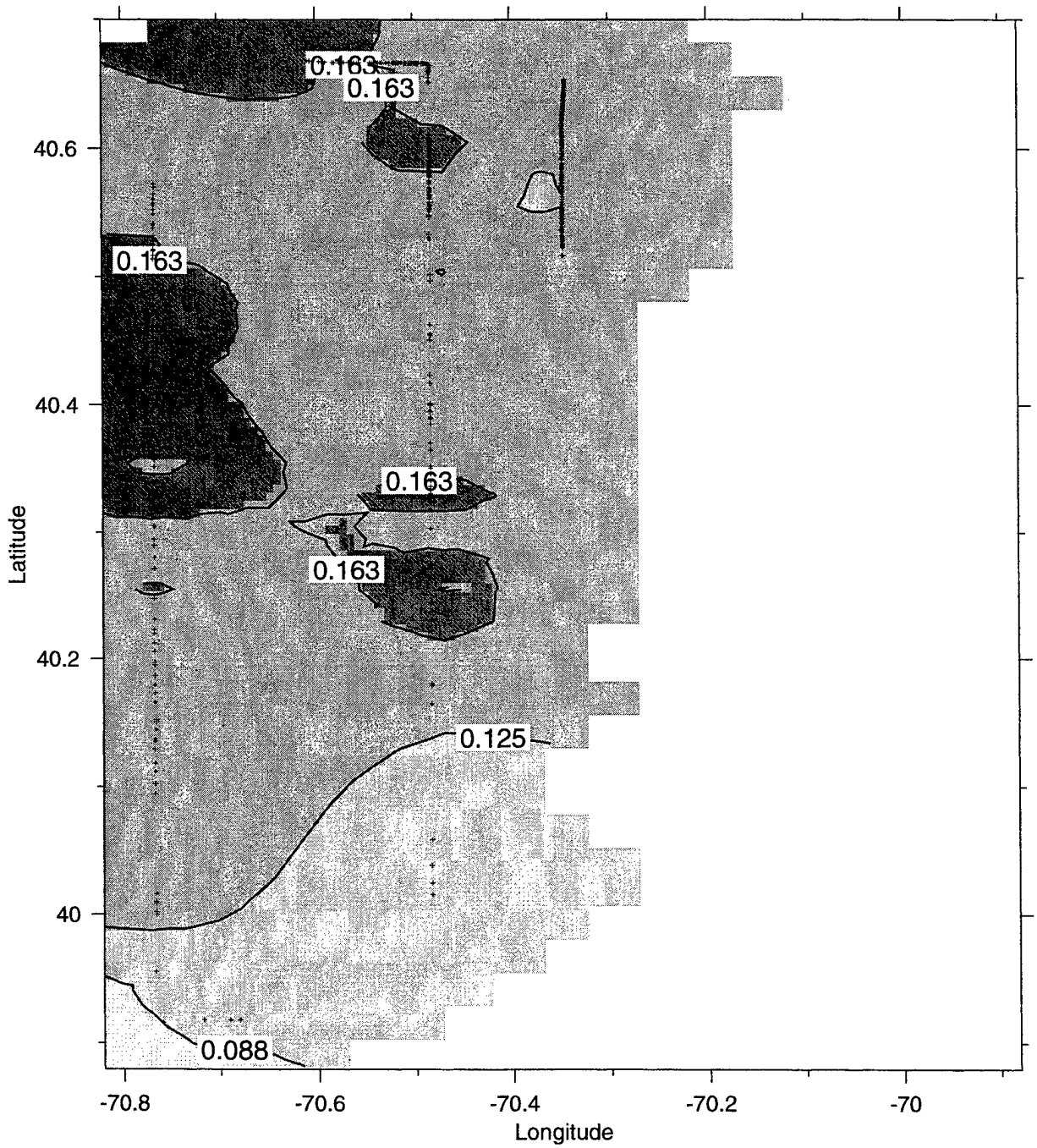


# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$**

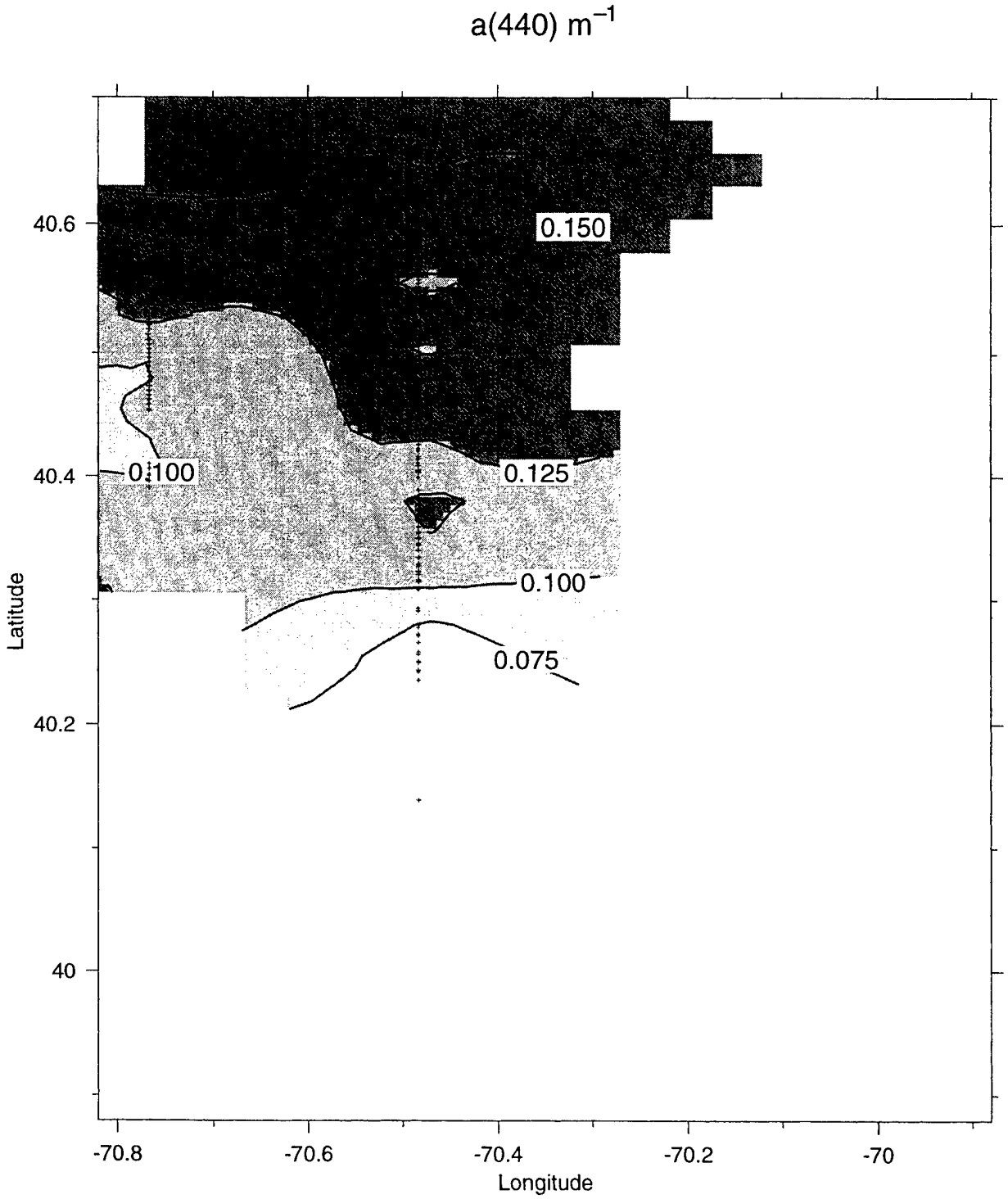
a(440) m$^{-1}$



# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

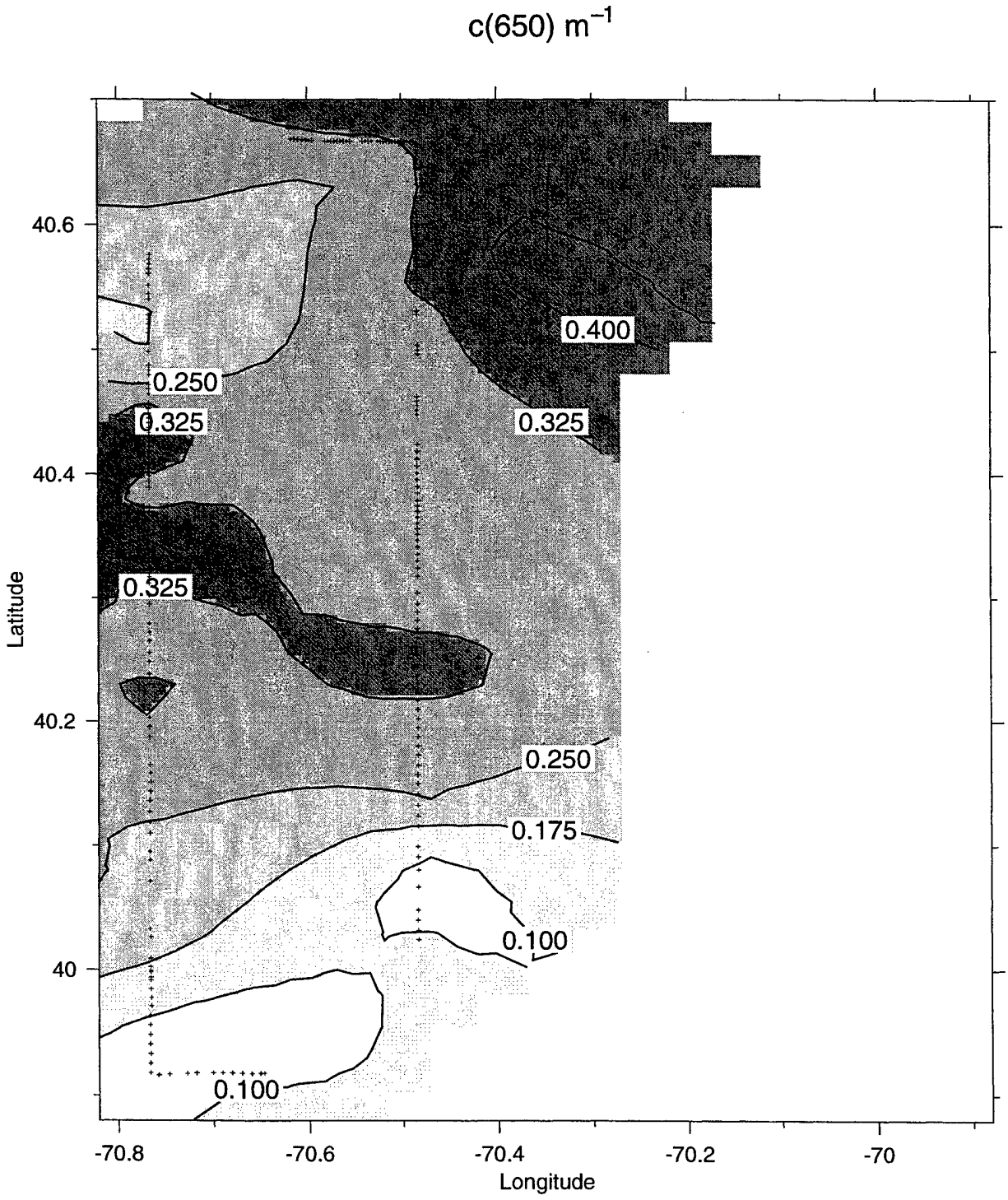
**Map view at 10 m above bottom**



# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

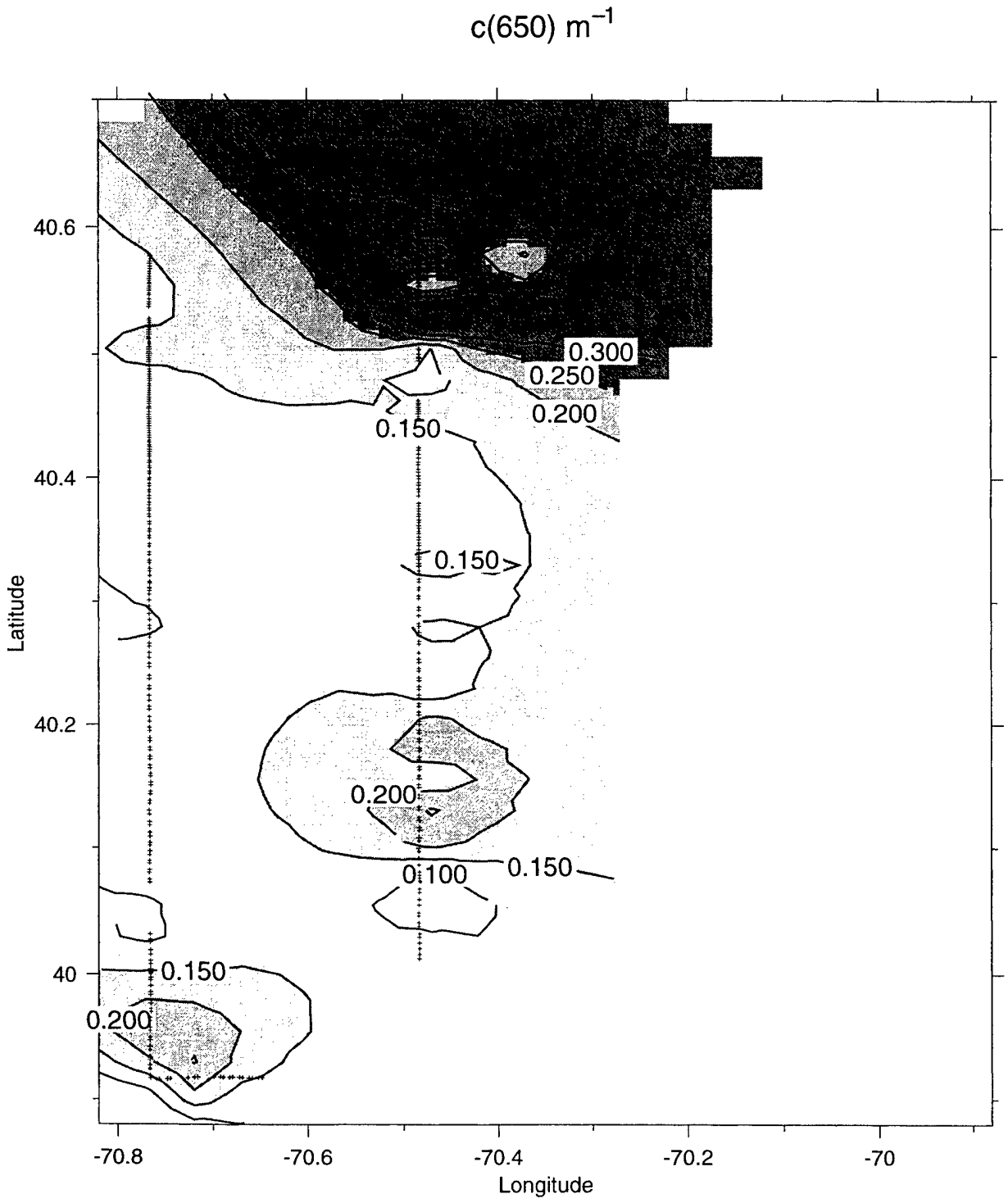
**Map view at 5 m**



# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

**Map view at 45 m**

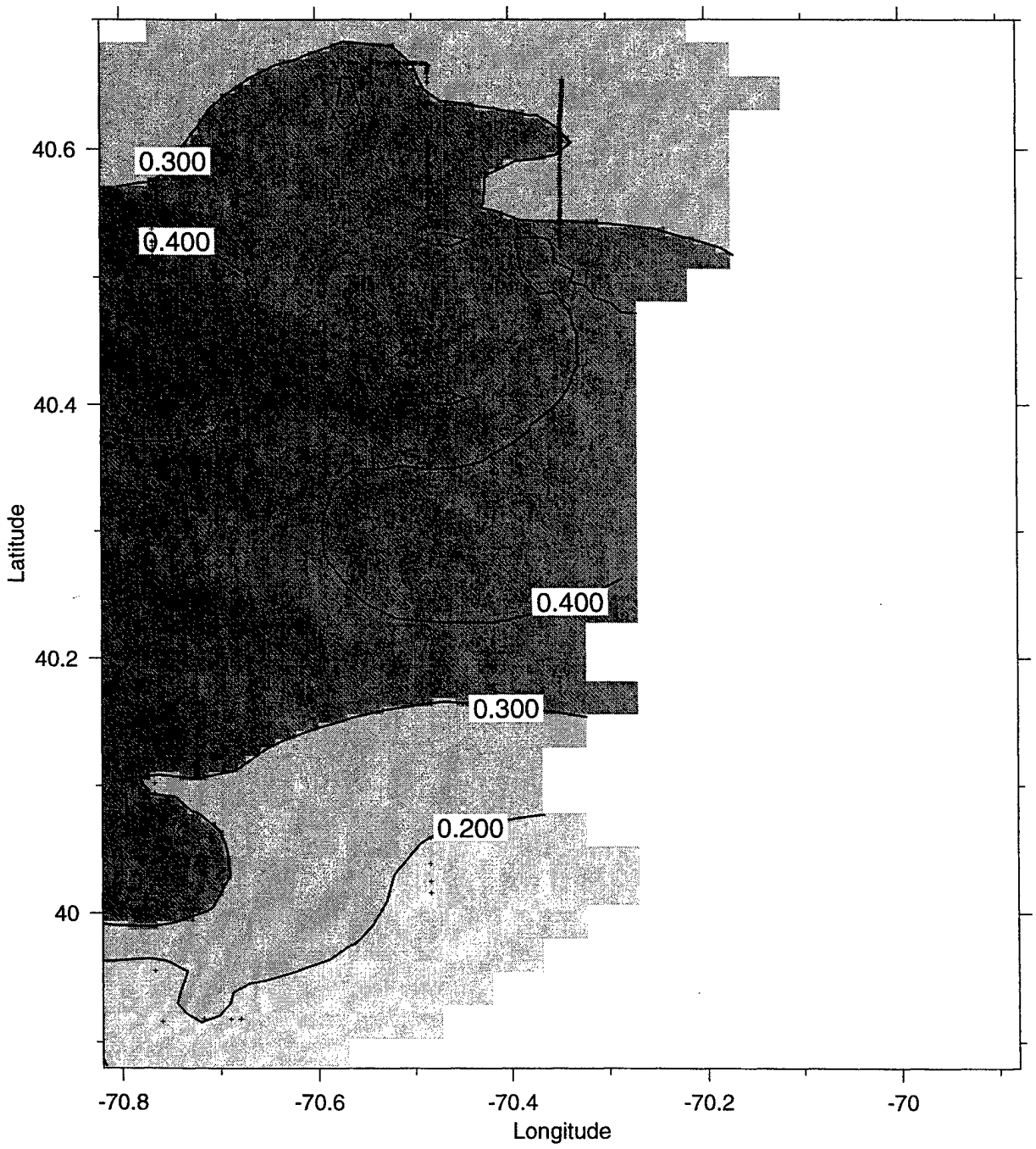


# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$**

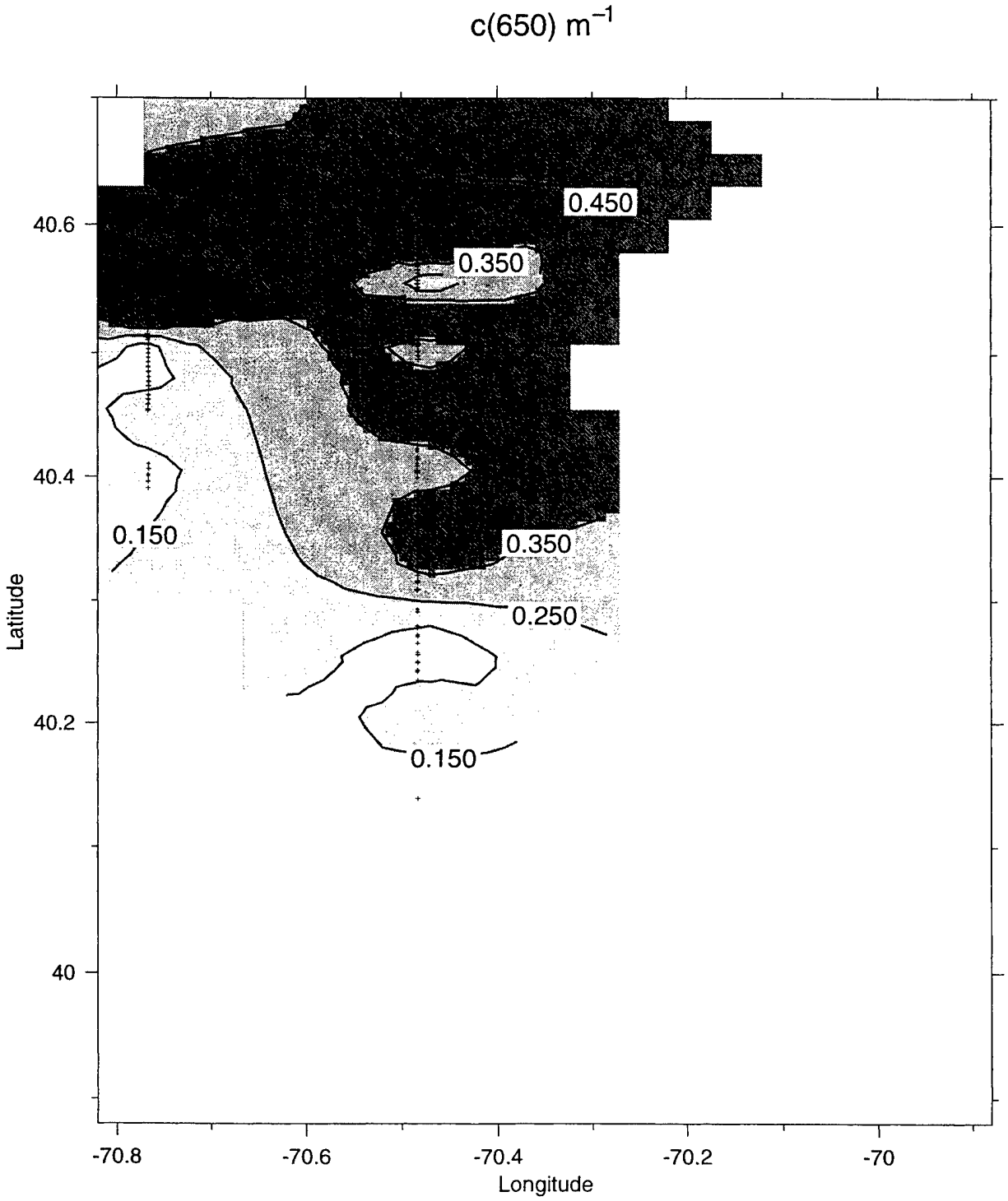
c(650) m$^{-1}$



# E9608 Bigbox 2

20-Aug-96 17:05 to 21-Aug-96 21:32

**Map view at 10 m above bottom**

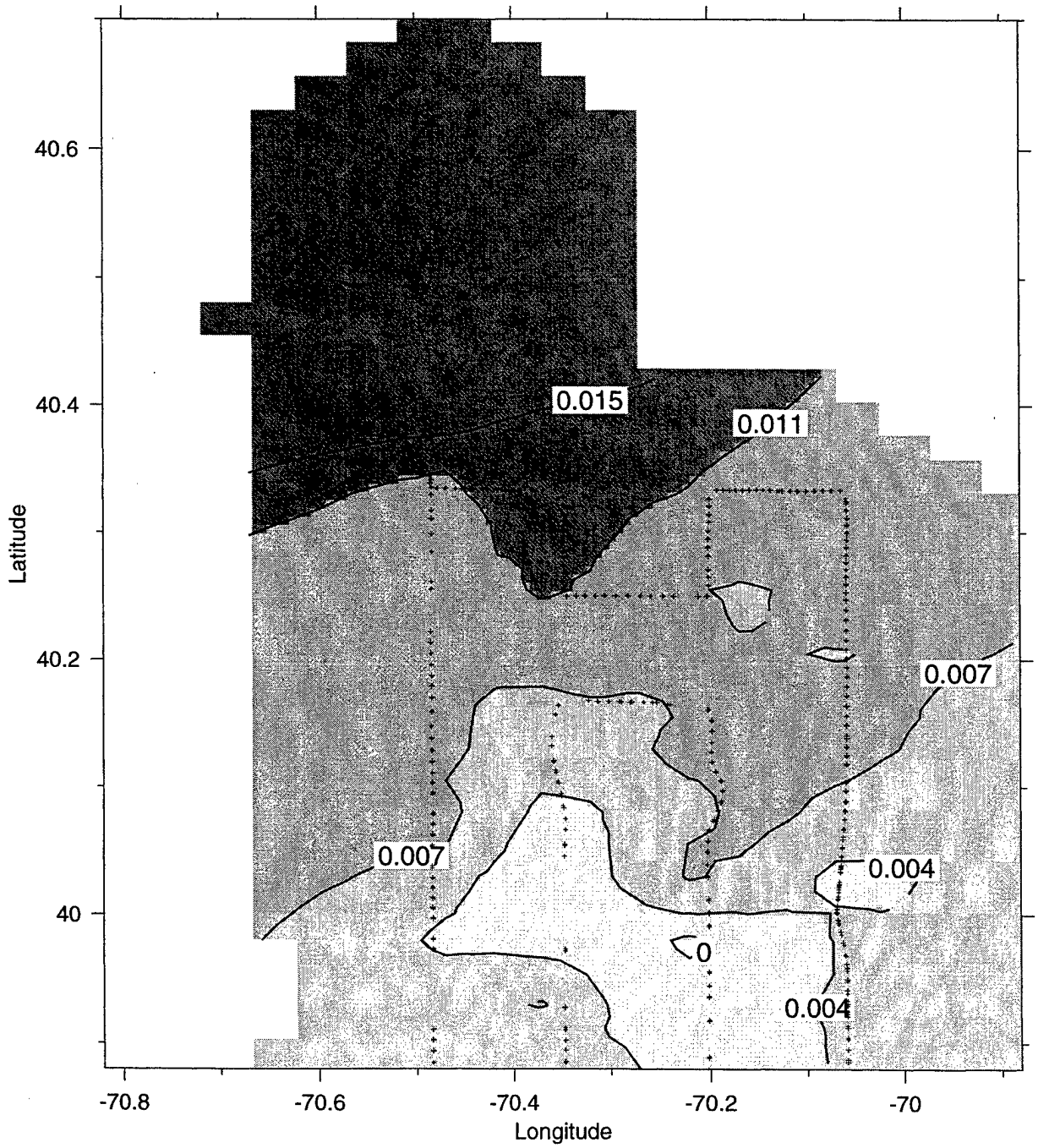


# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

**Map view at 5 m**

a(676) $m^{-1}$

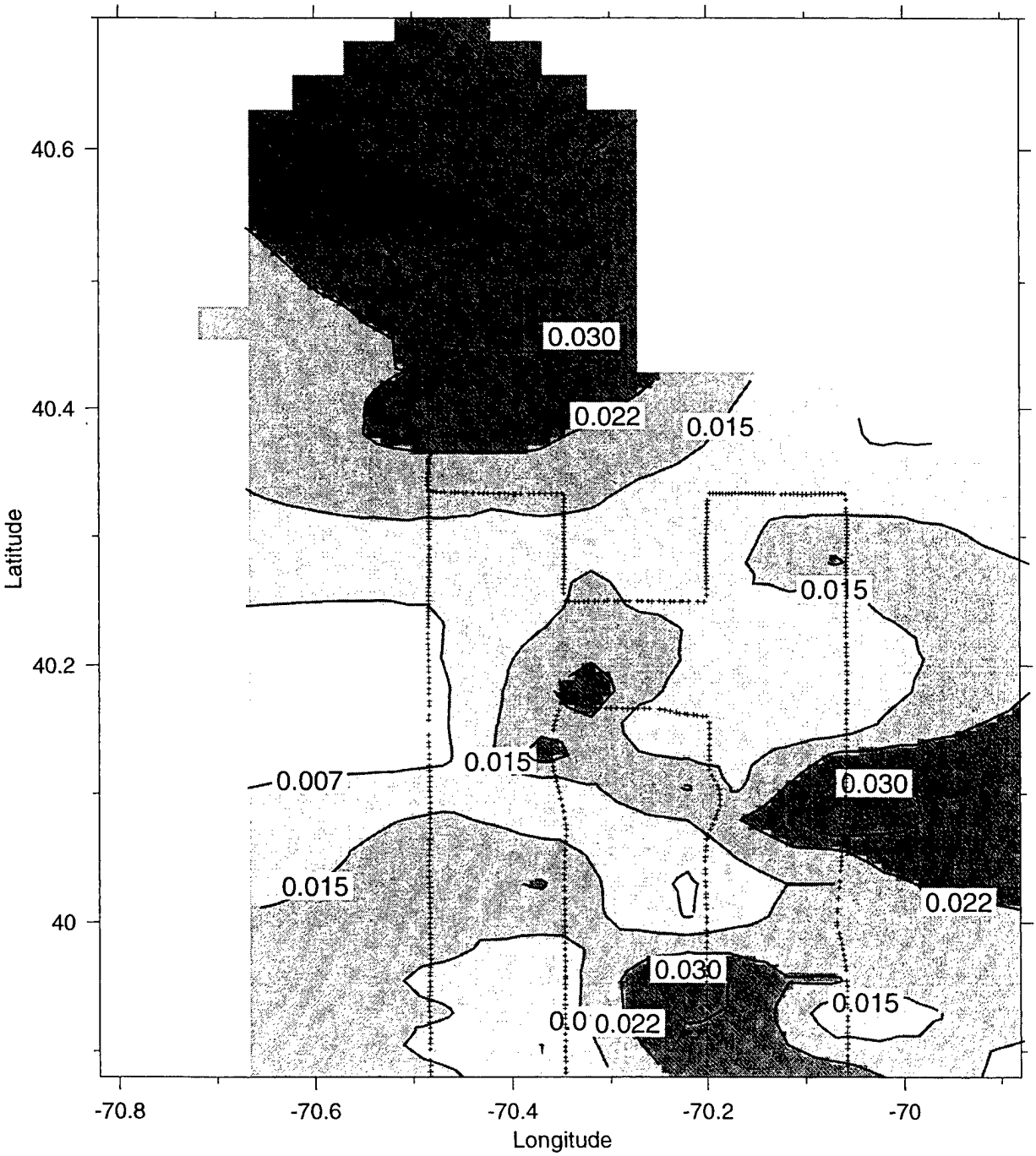


# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

**Map view at 45 m**

a(676) $m^{-1}$

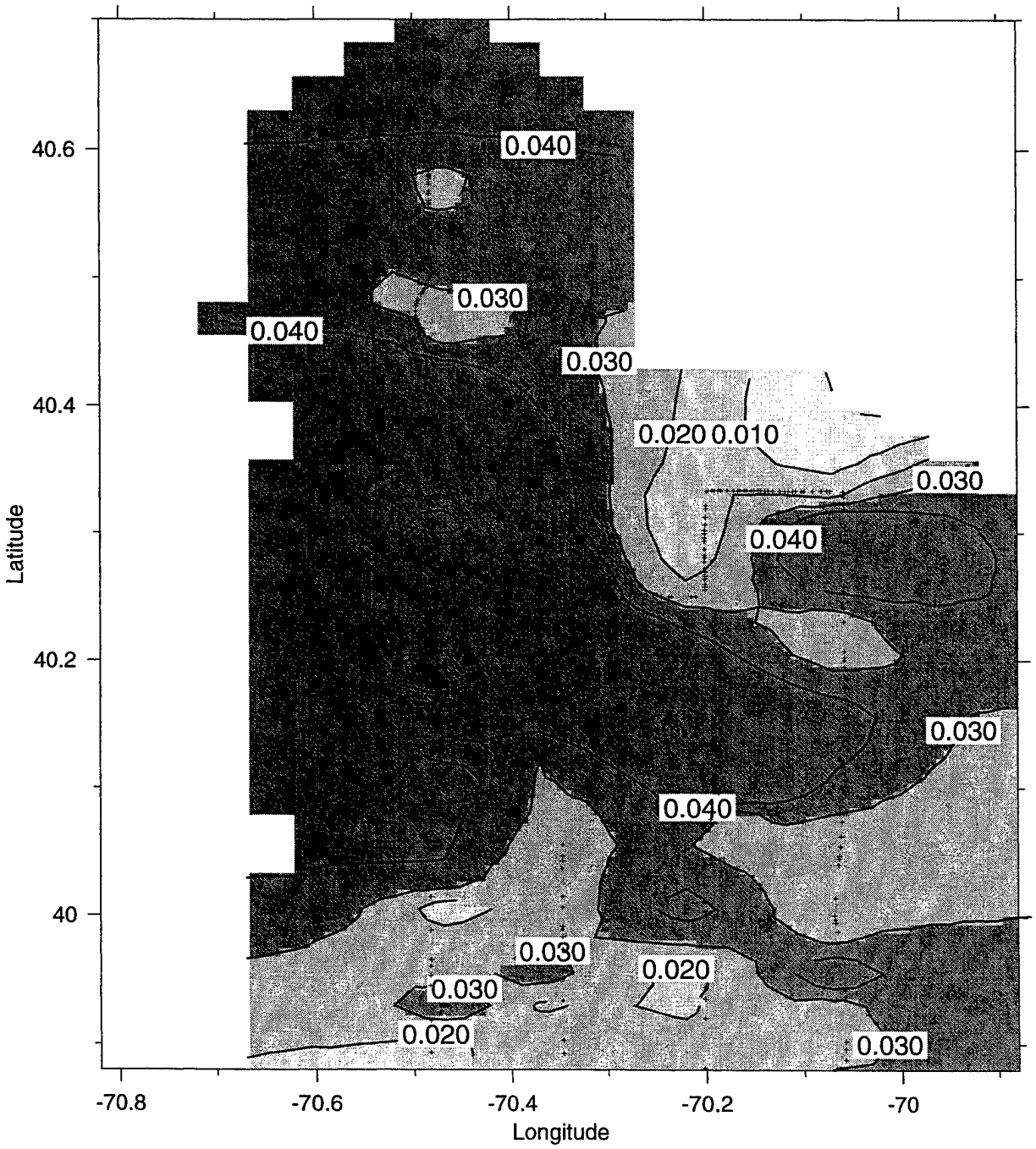


# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$**

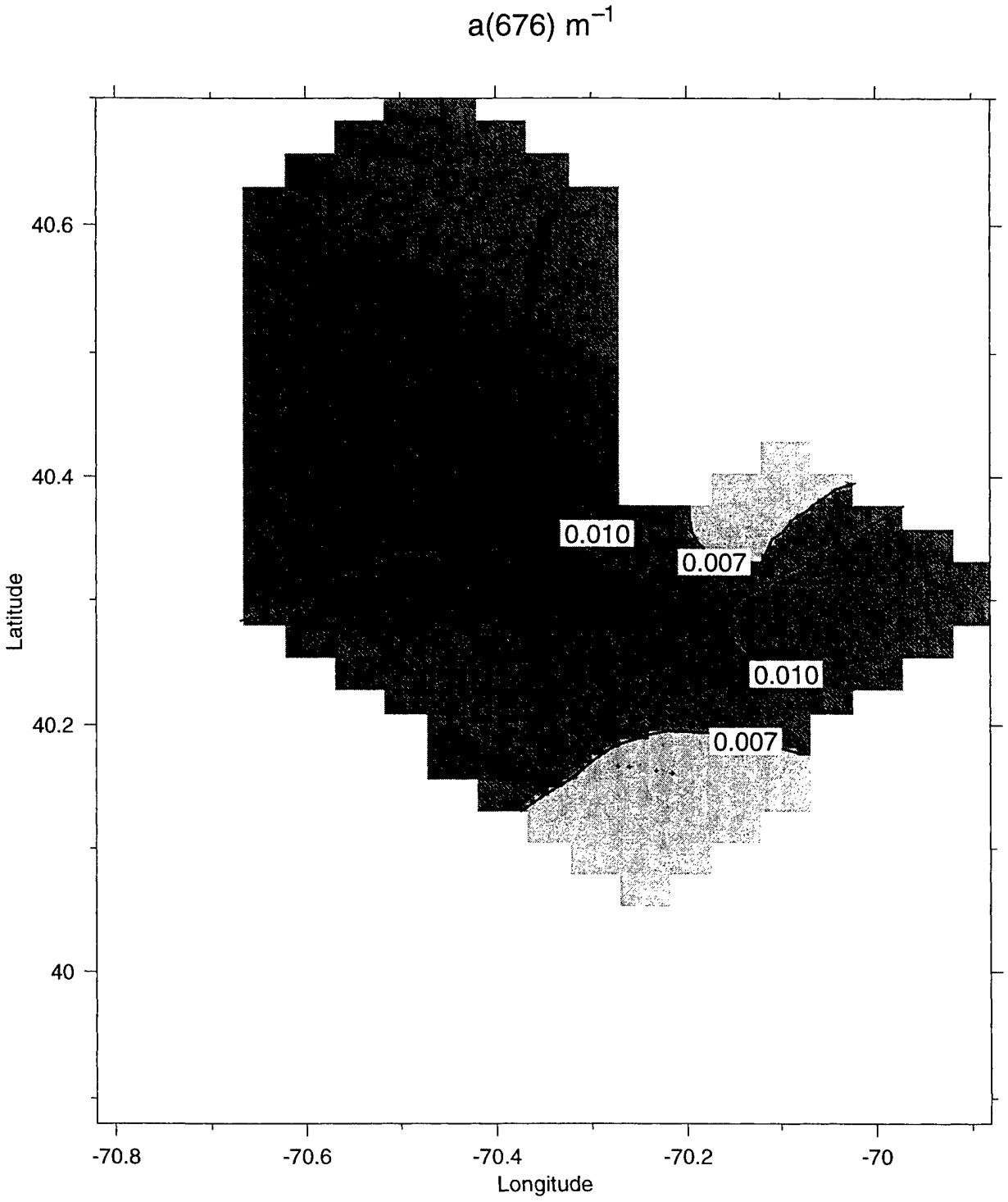
a(676) m$^{-1}$



# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

**Map view at 10 m above bottom**

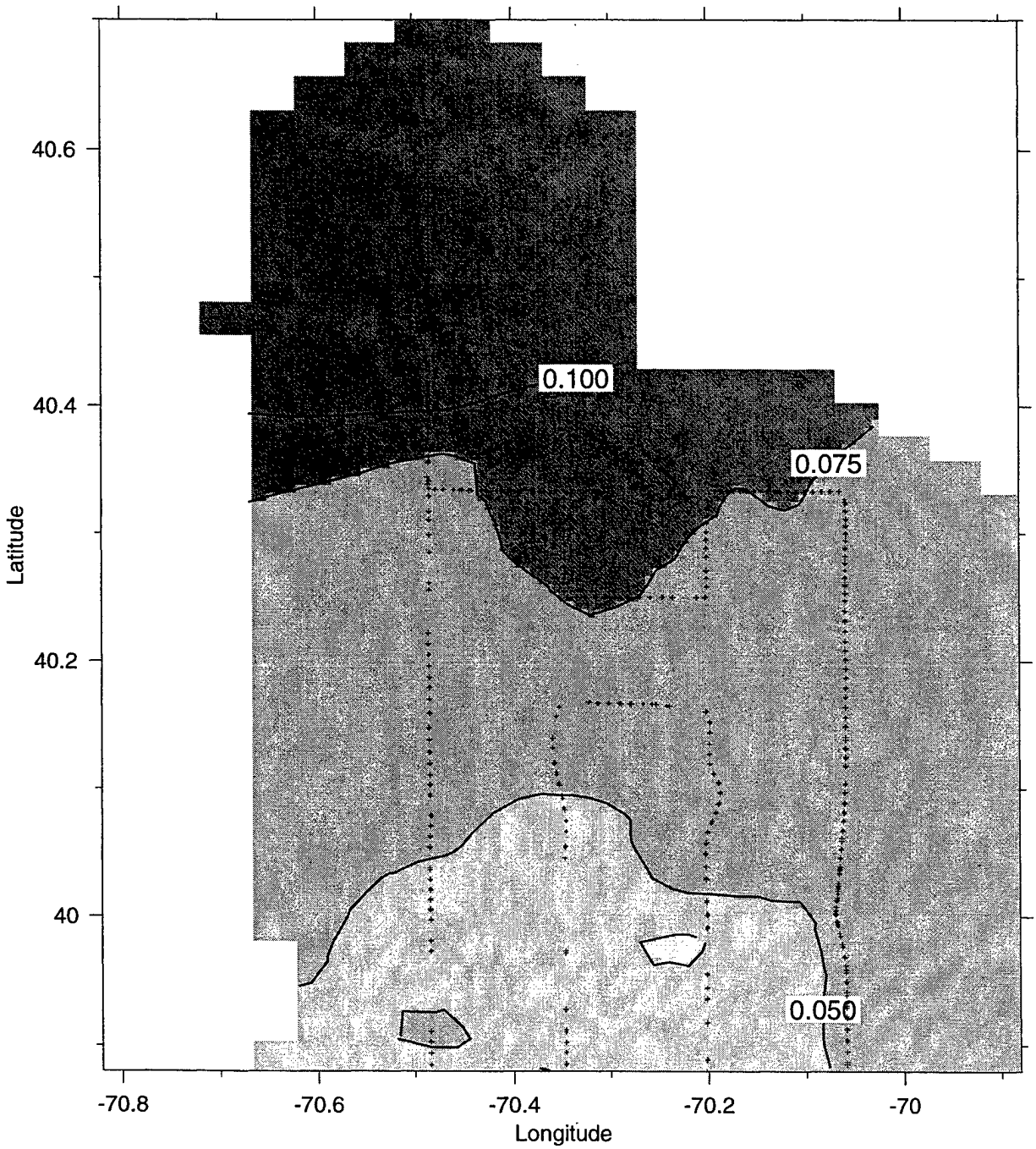


# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

**Map view at 5 m**

a(440) $m^{-1}$

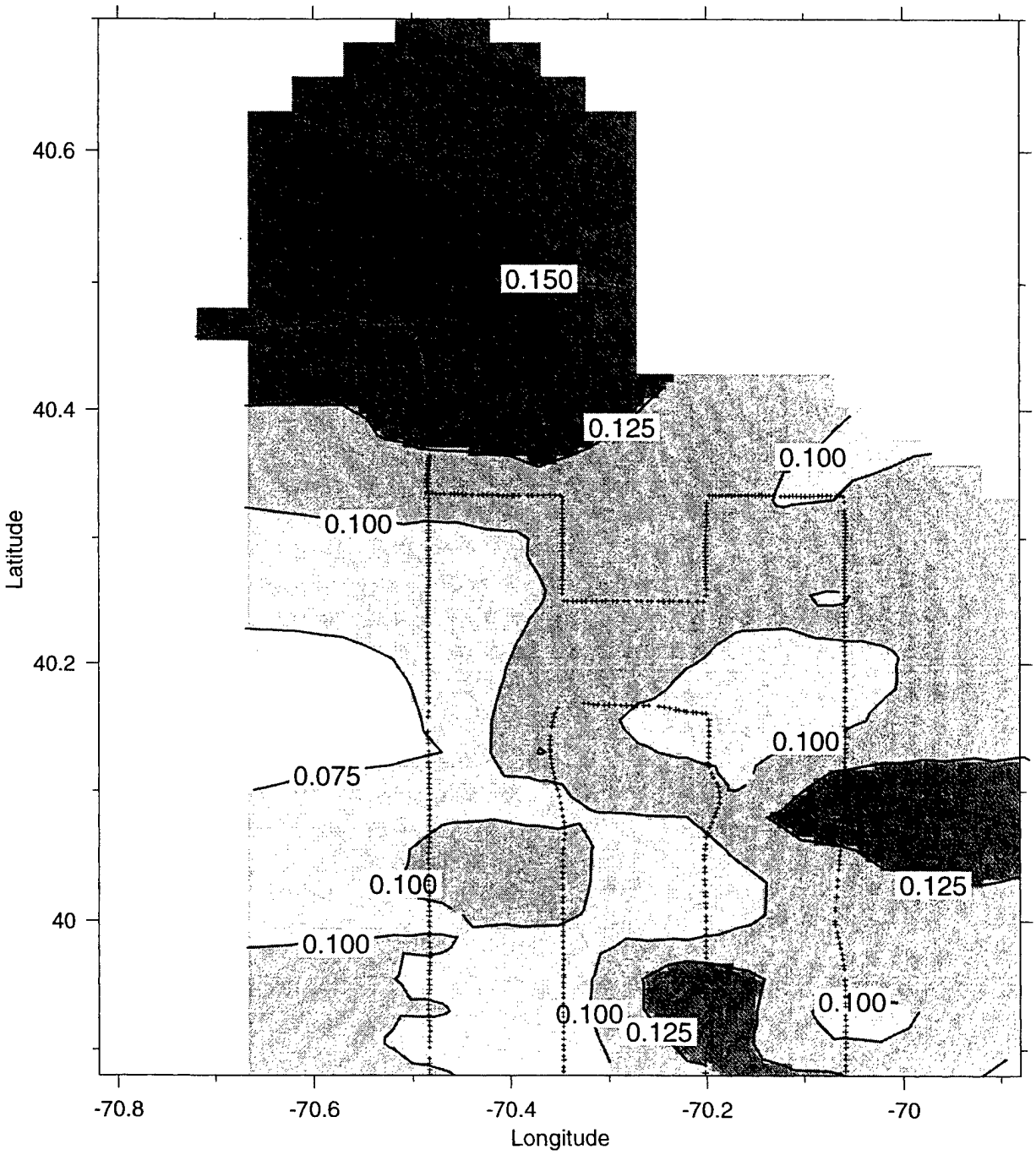


# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

**Map view at 45 m**

a(440) $m^{-1}$

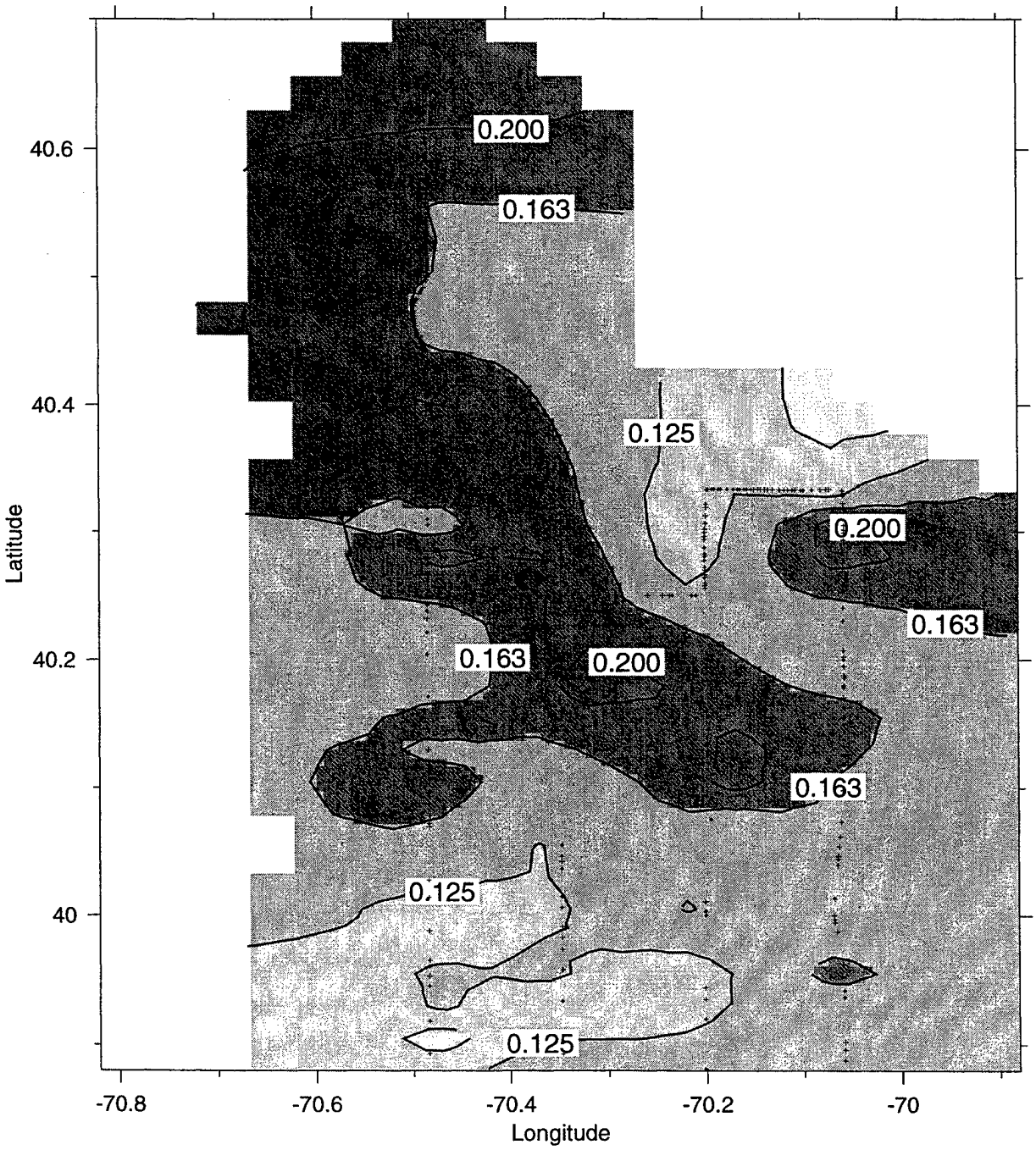


# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

**Map view at $\sigma_t$ = 24.6 ± 0.025 kg/m$^3$**

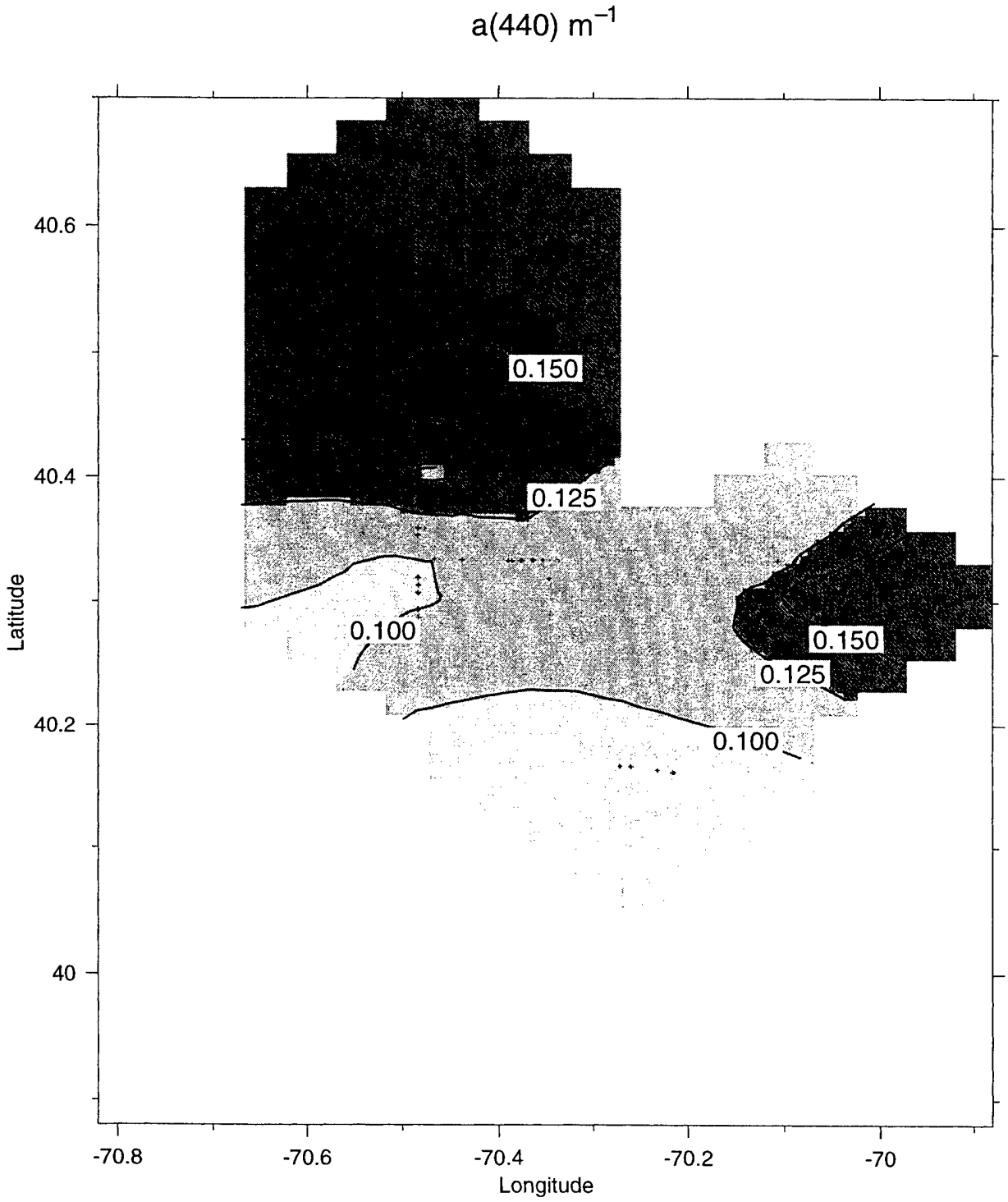
a(440) m$^{-1}$



# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

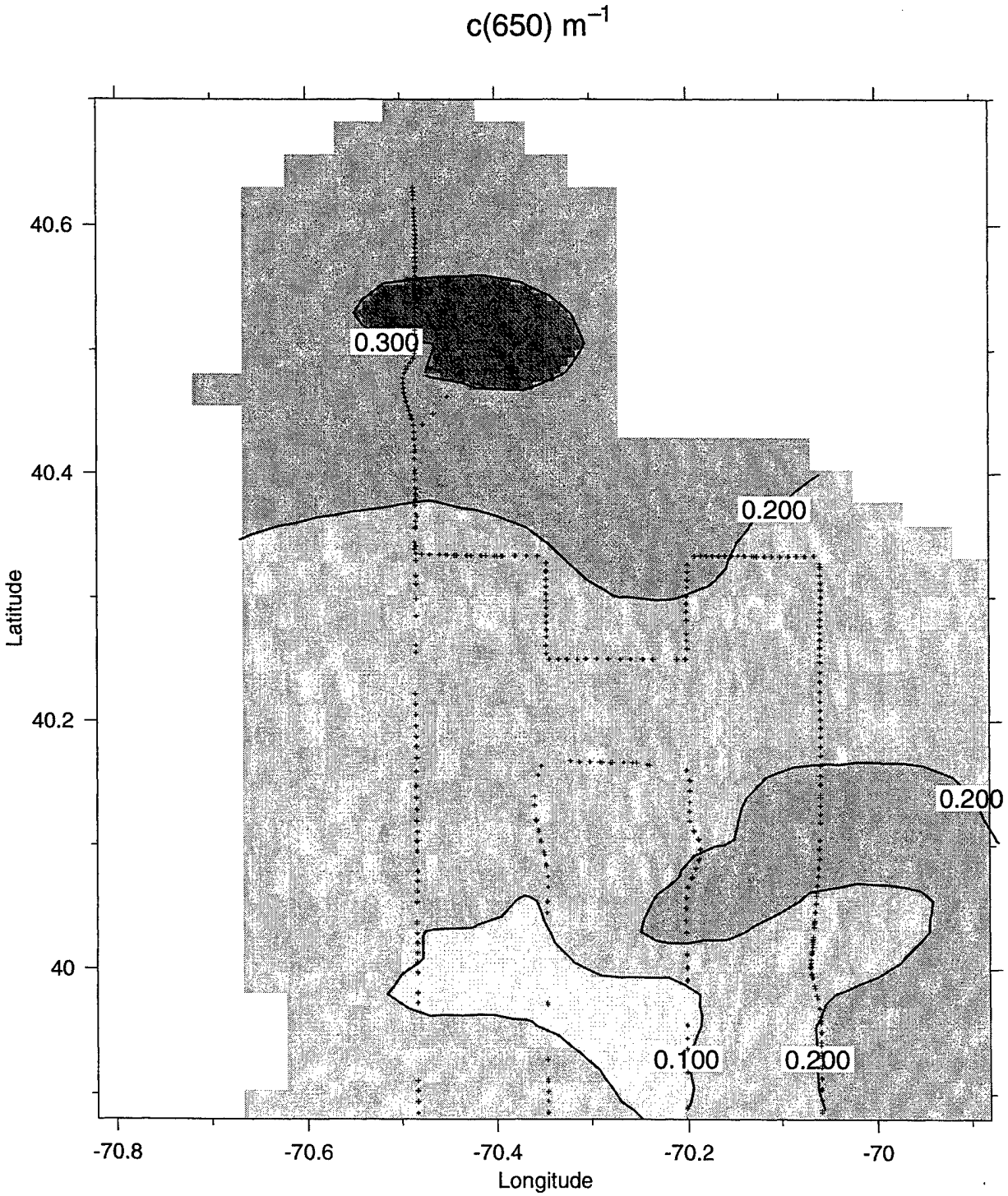
**Map view at 10 m above bottom**



# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

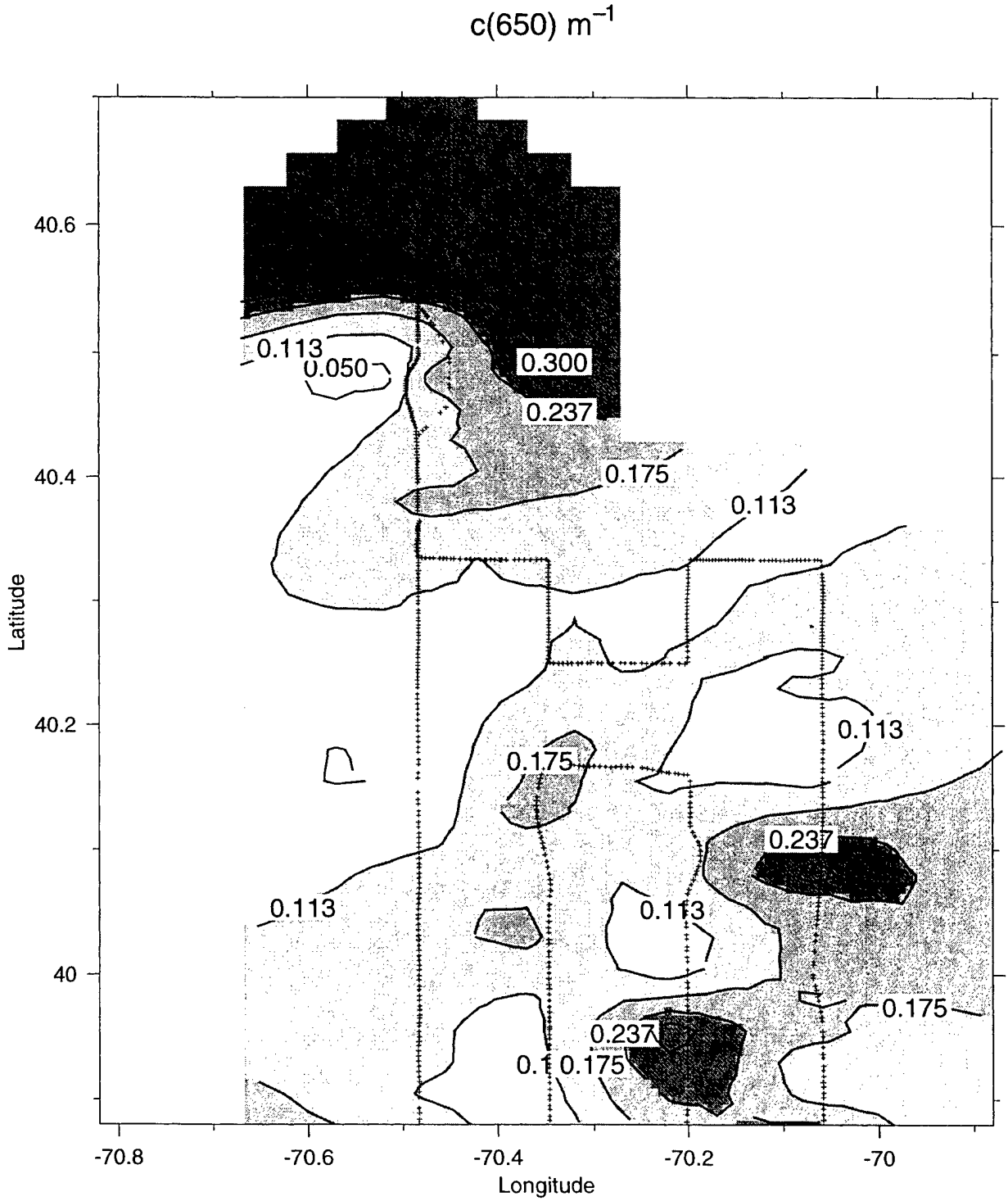
**Map view at 5 m**



# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

**Map view at 45 m**

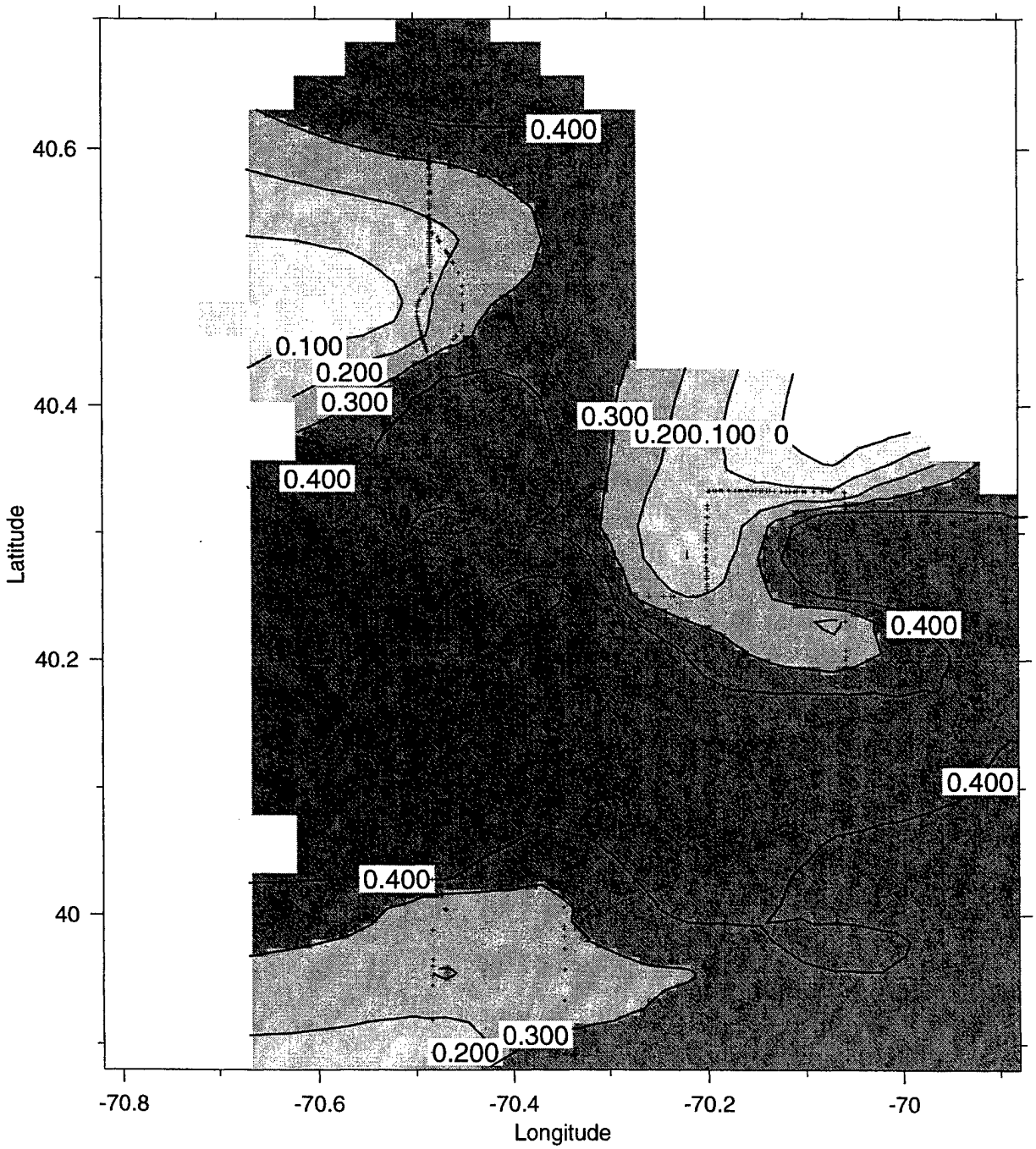


# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$**

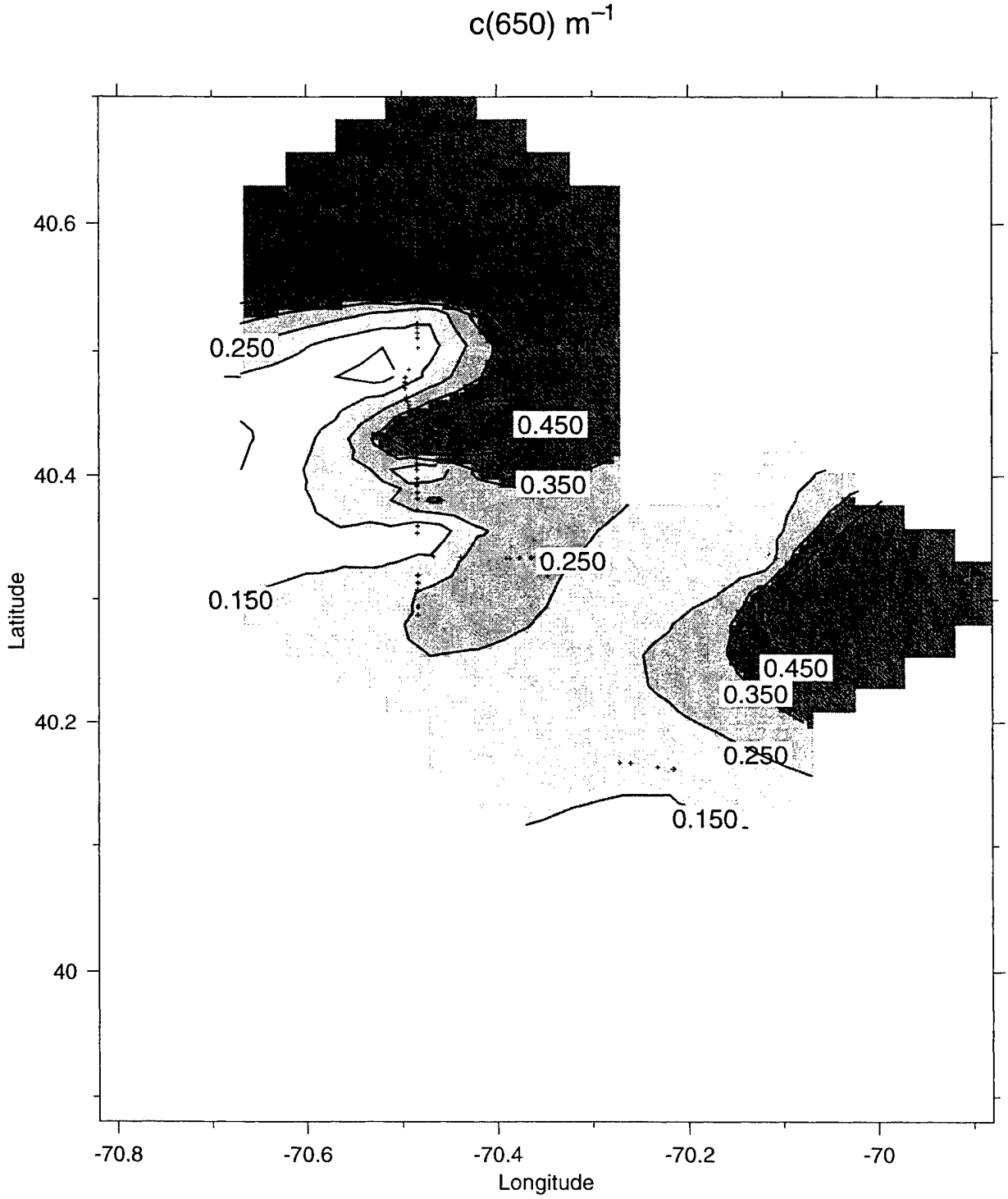
c(650) m$^{-1}$



# E9608 Bigbox 3

31-Aug-96 05:52 to 01-Sep-96 11:05

**Map view at 10 m above bottom**

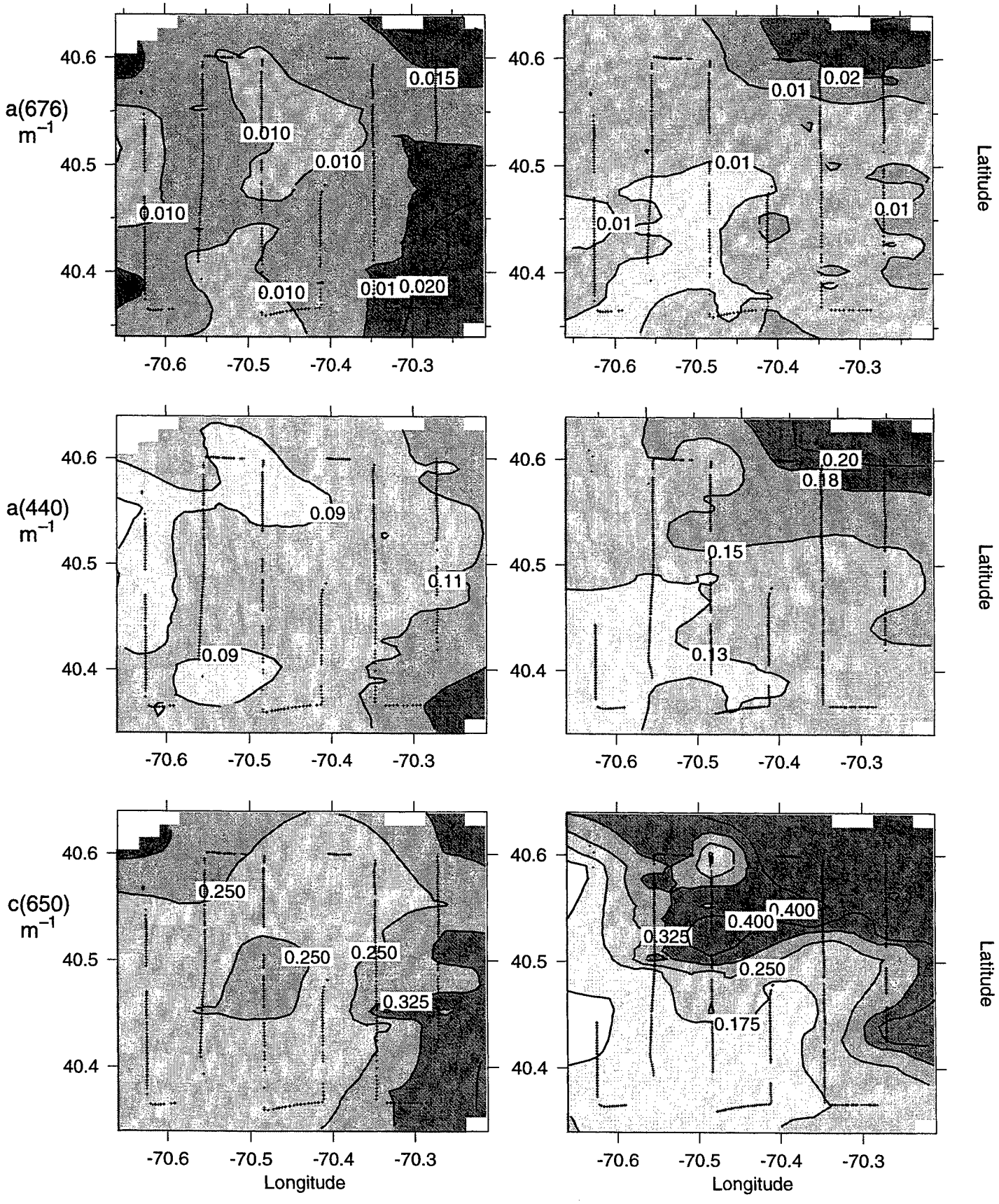


# E9608 Smallbox Maps

# E9608 Smallbox 1

15-Aug-96 23:26 to 16-Aug-96 15:26

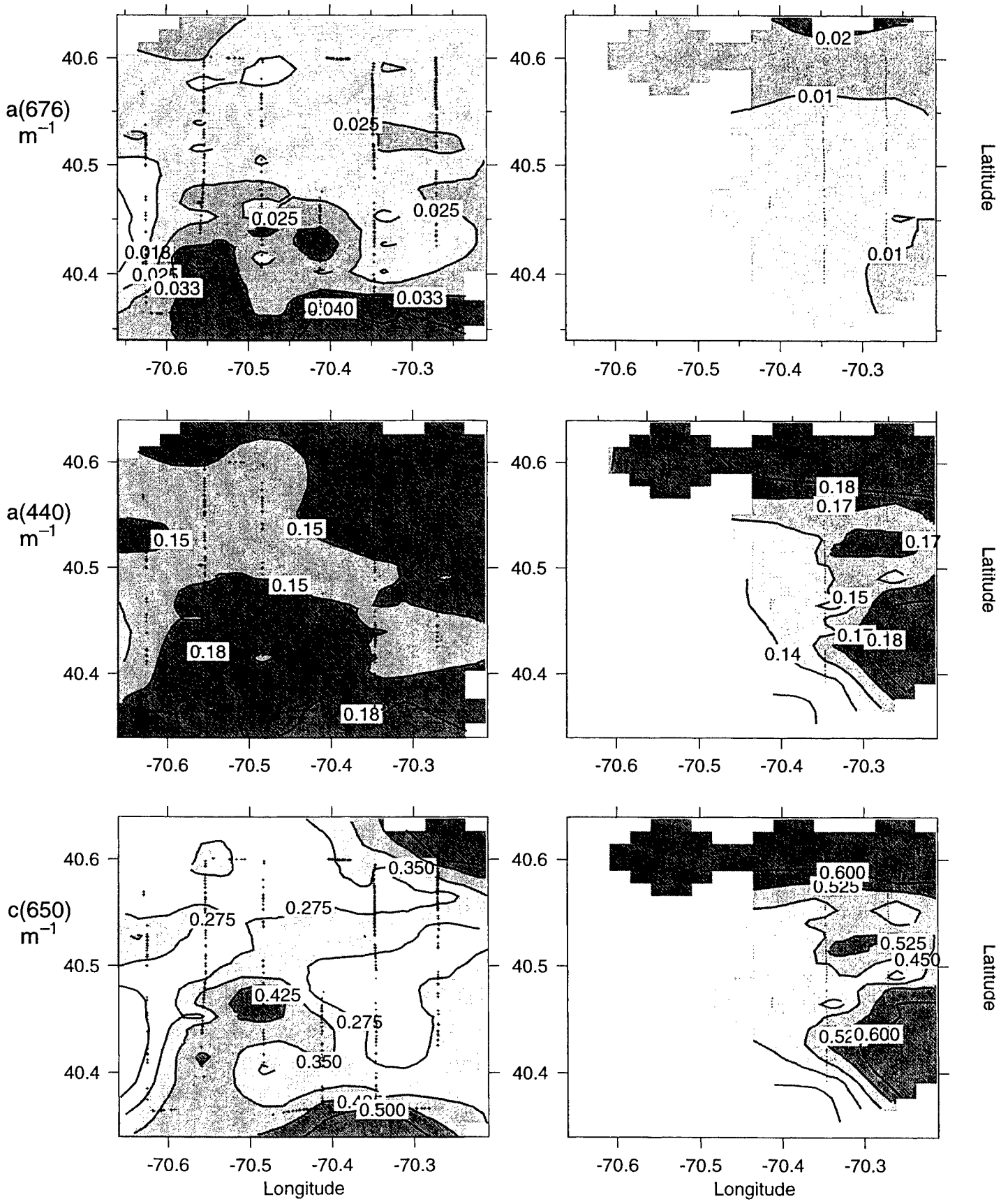
**Map view at 5 m** **Map view at 45 m**



# E9608 Smallbox 1

15-Aug-96 23:26 to 16-Aug-96 15:26

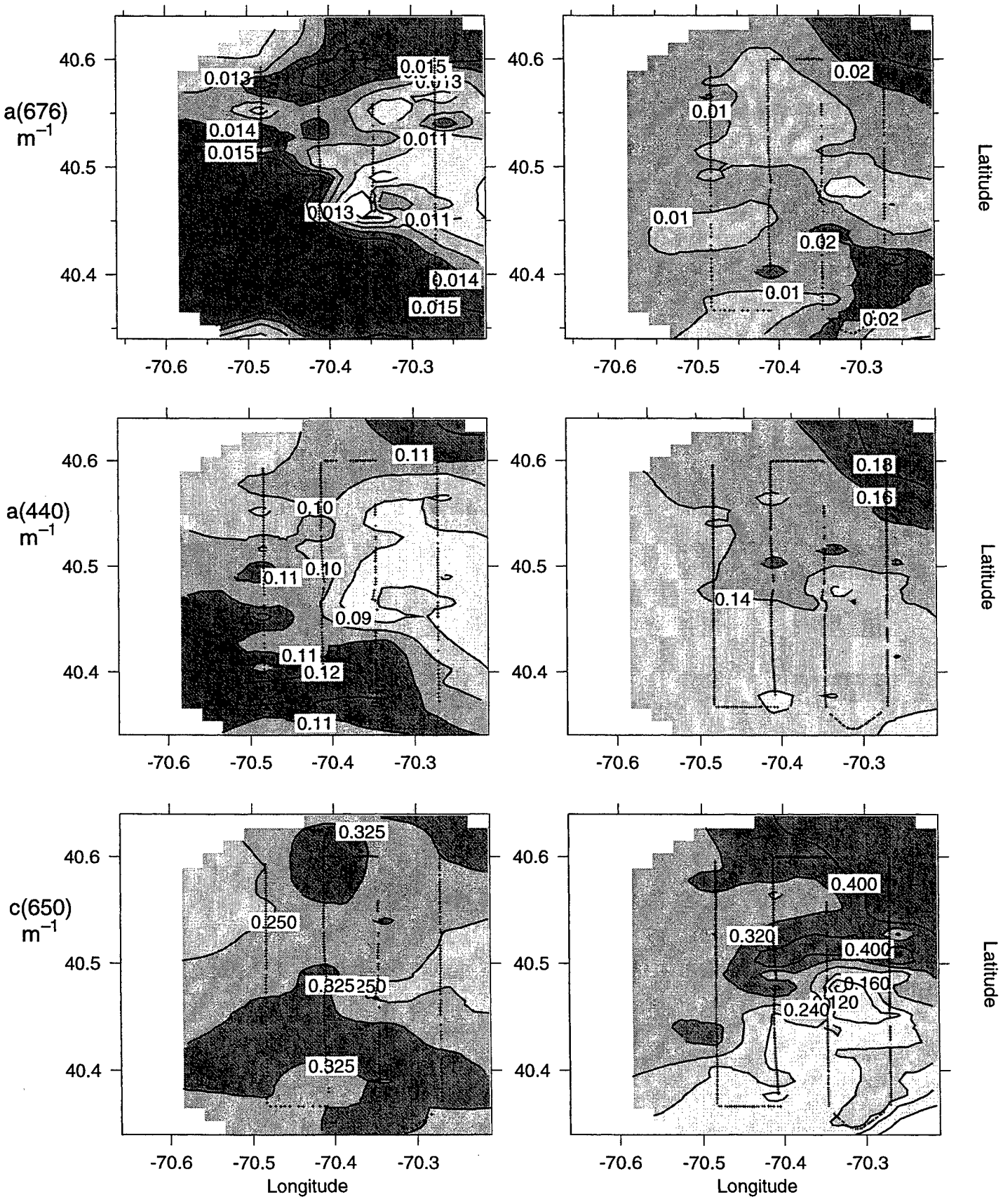
**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**



# E9608 Smallbox 2

18-Aug-96 14:13 to 19-Aug-96 01:36

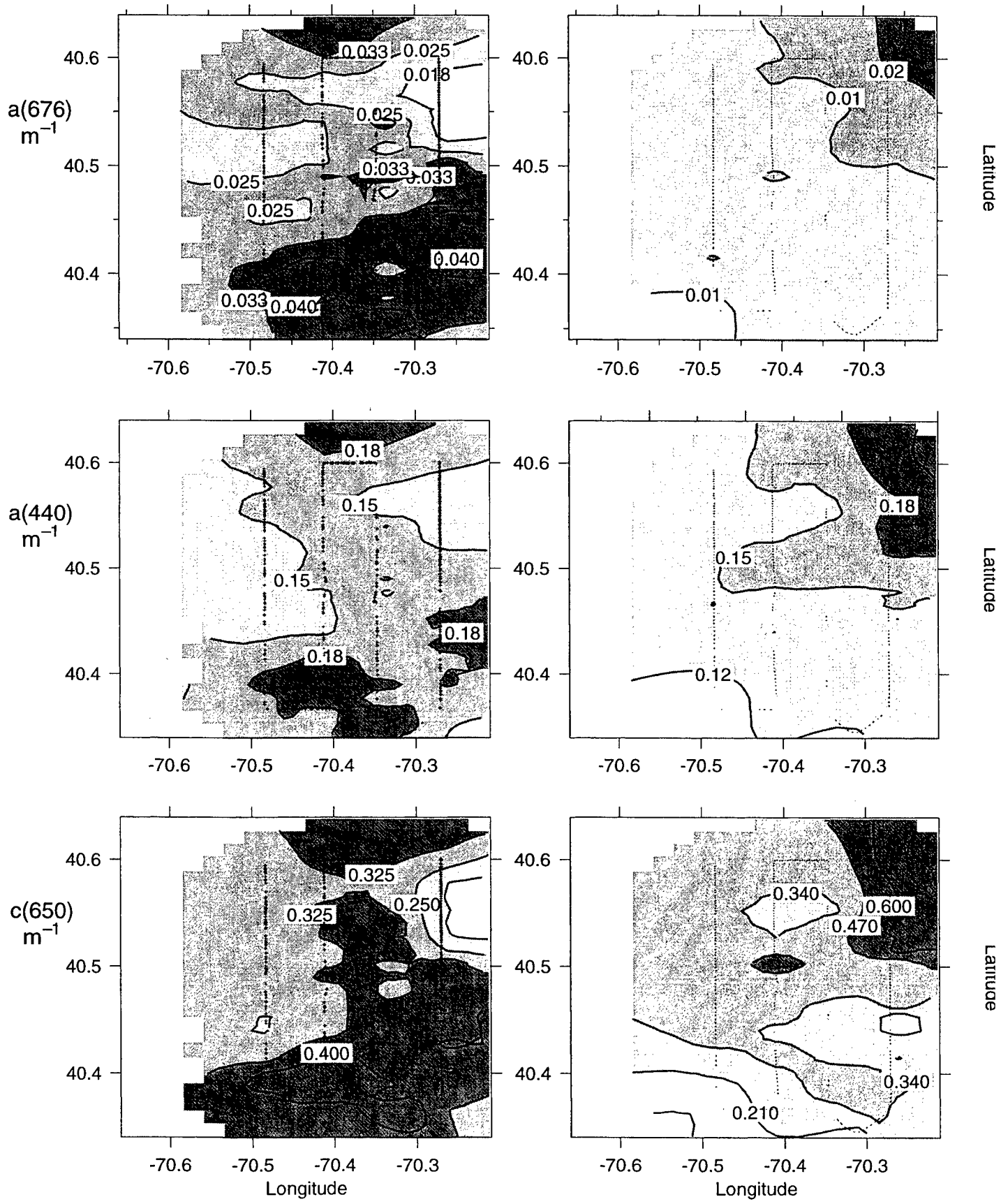
**Map view at 5 m** **Map view at 45 m**



# E9608 Smallbox 2

18-Aug-96 14:13 to 19-Aug-96 01:36

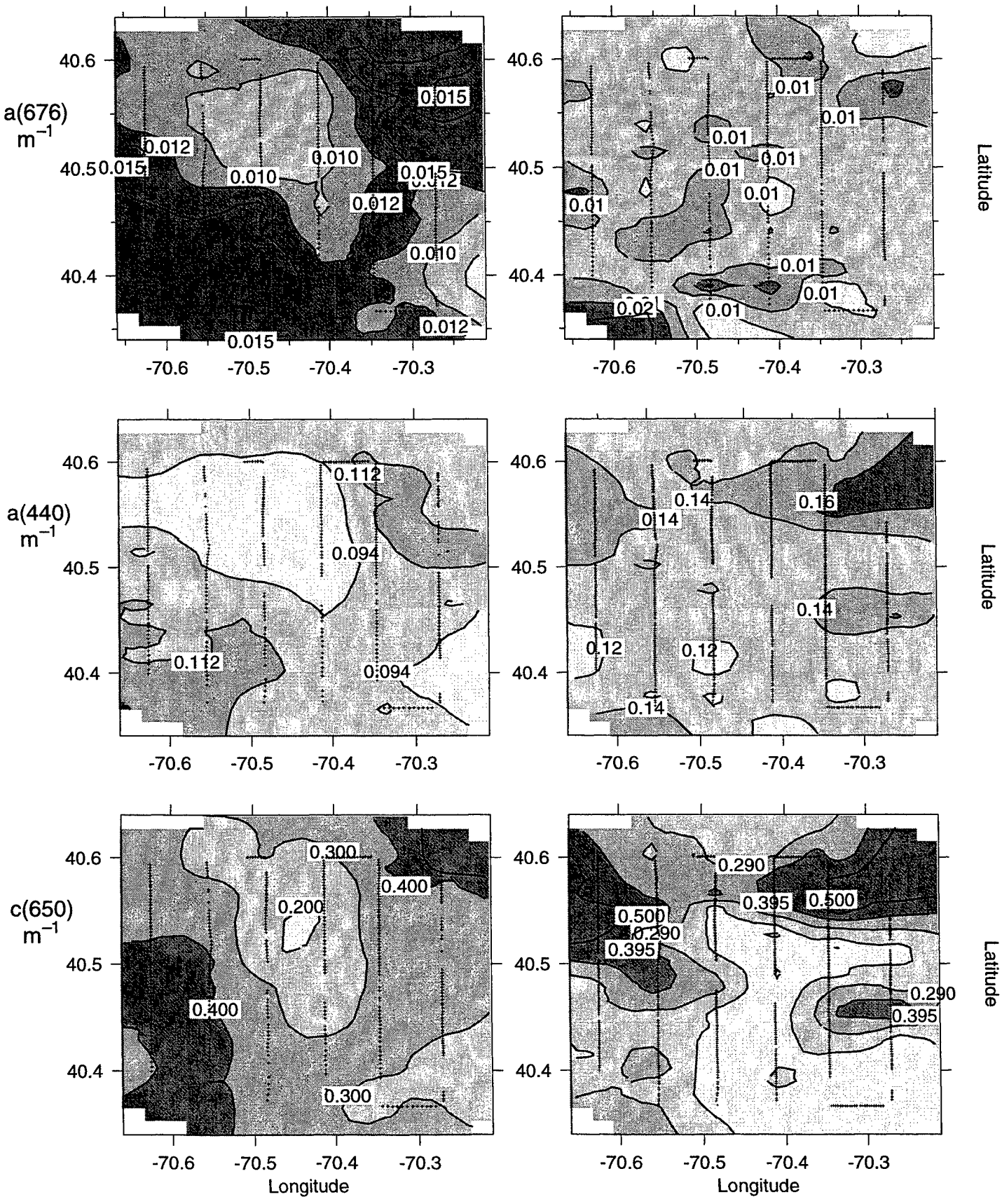
**Map view at $\sigma_t$ = 24.6 ± 0.025 kg/m$^3$** **Map view at 10 m above the bottom**



# E9608 Smallbox 3

20-Aug-96 01:41 to 20-Aug-96 14:32

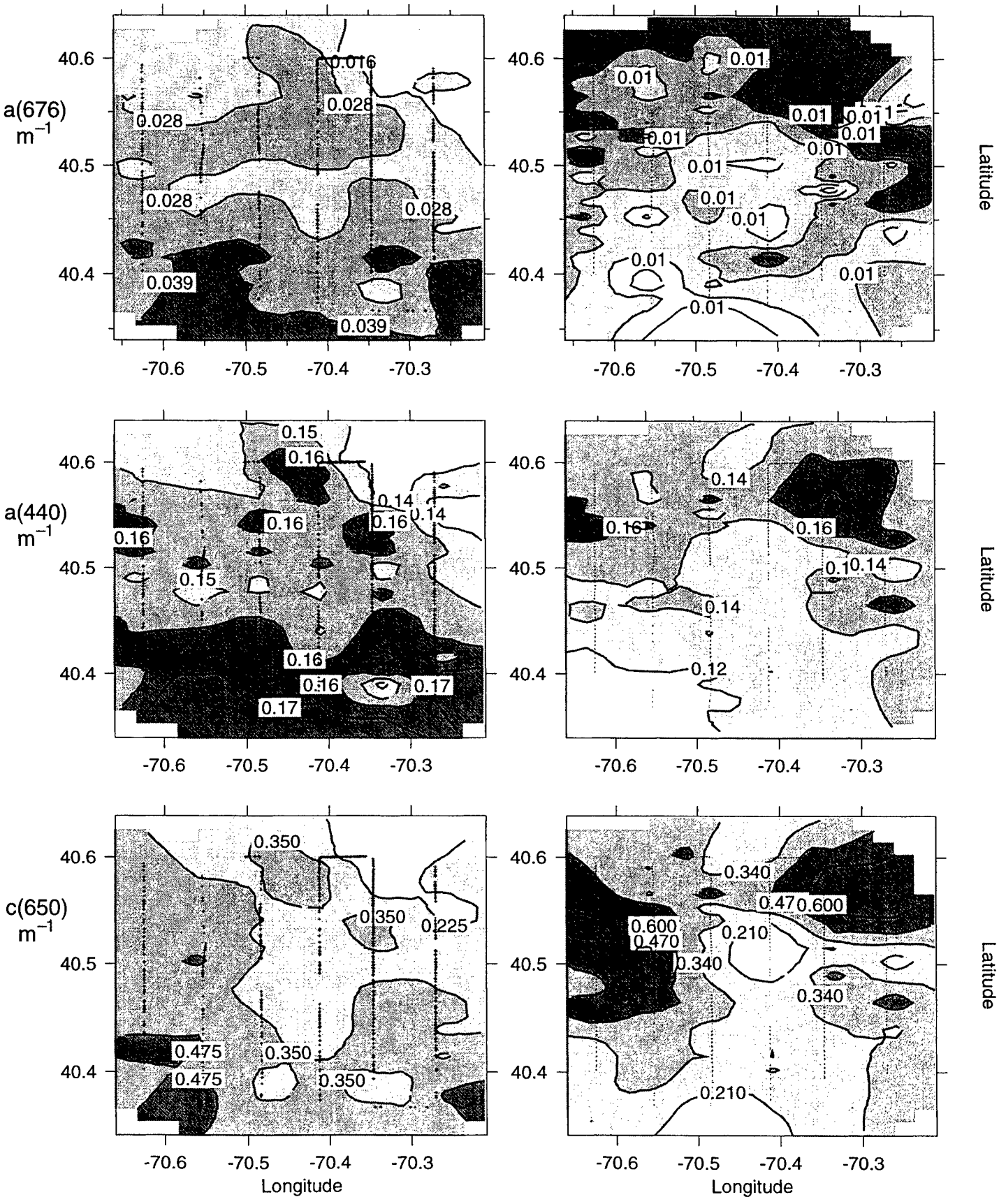
**Map view at 5 m** **Map view at 45 m**



# E9608 Smallbox 3

20-Aug-96 01:41 to 20-Aug-96 14:32

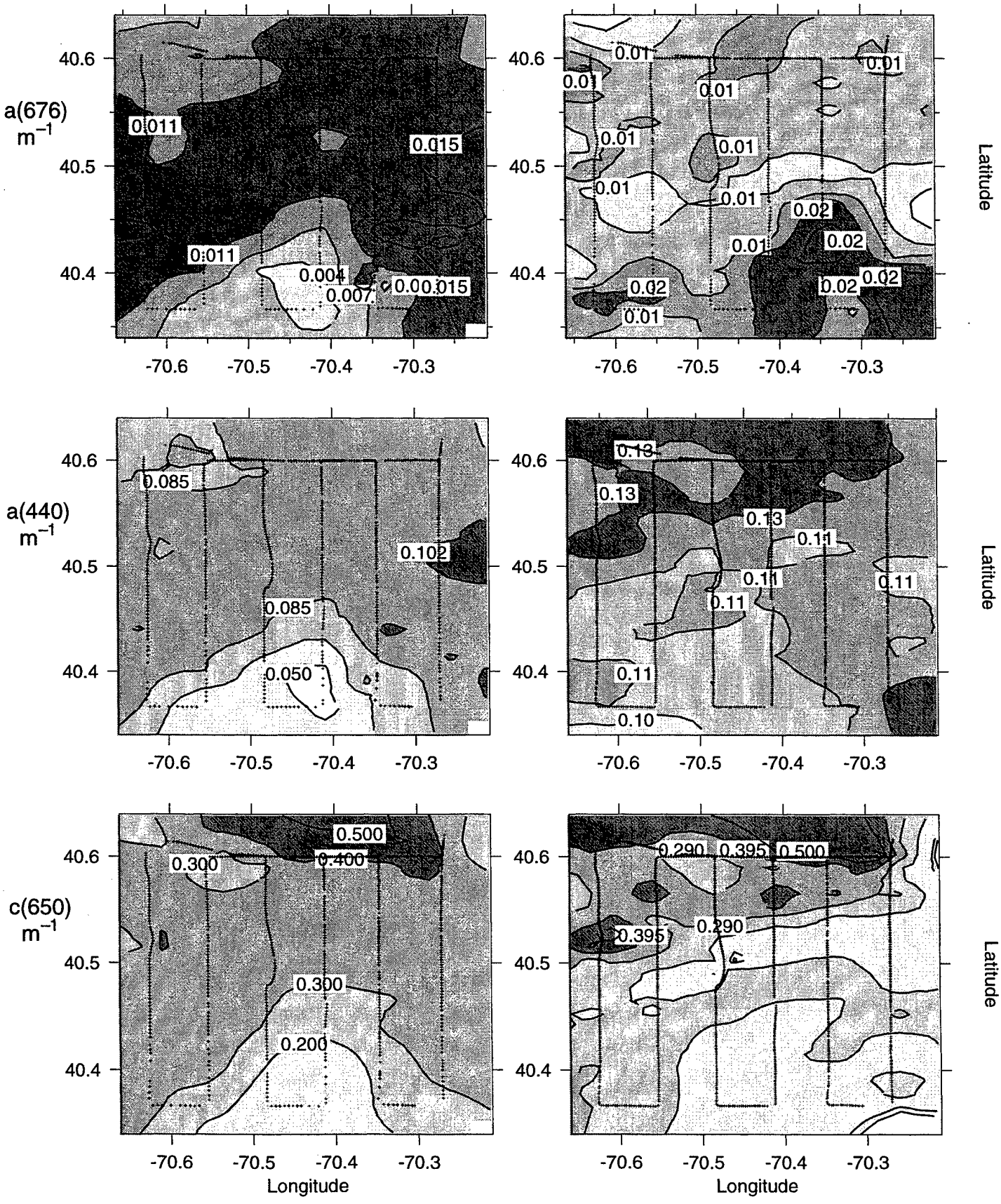
**Map view at $\sigma_t$ = 24.6 ± 0.025 kg/m$^3$** **Map view at 10 m above the bottom**



# E9608 Smallbox 4

24-Aug-96 20:05 to 25-Aug-96 11:34

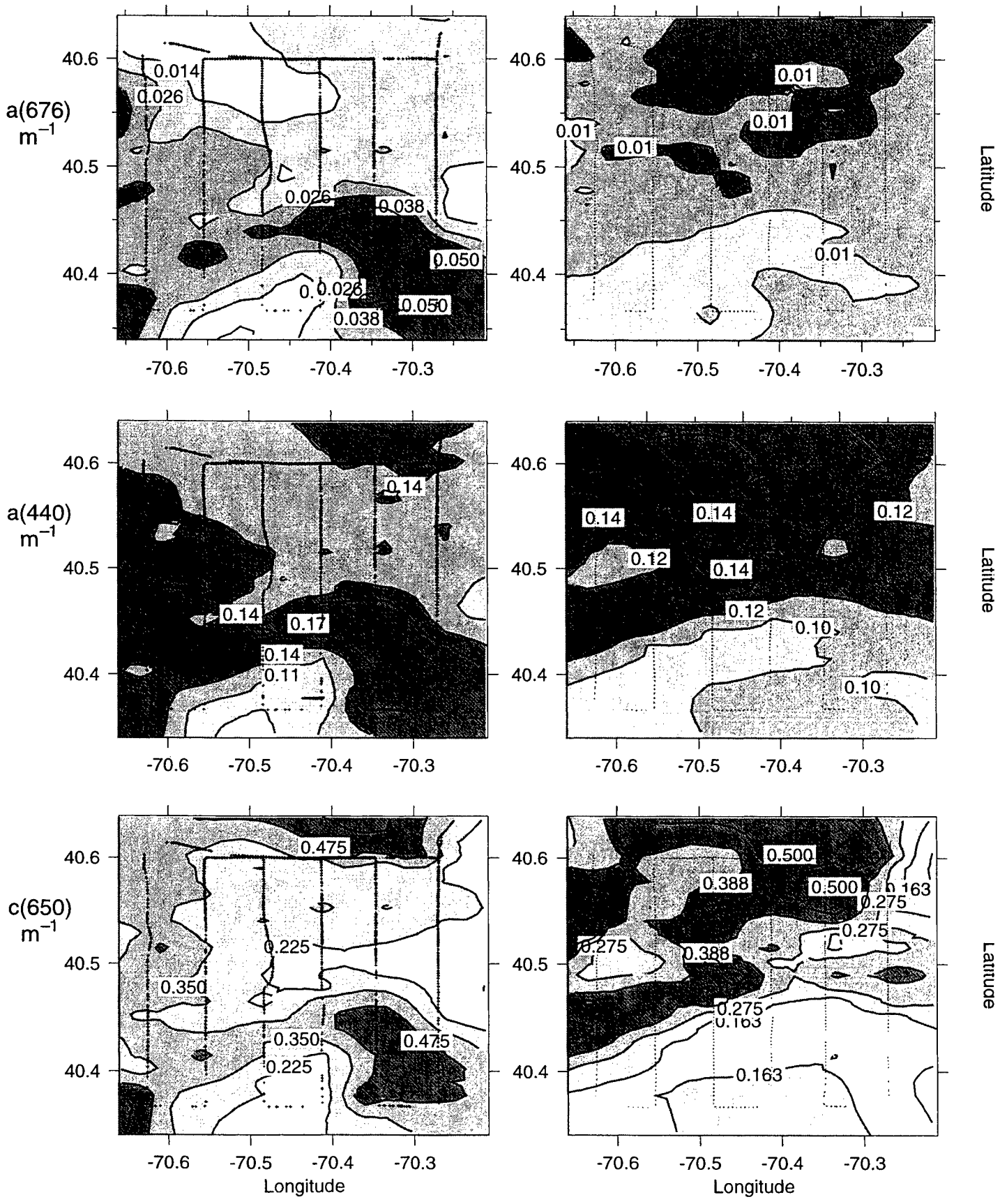
**Map view at 5 m** **Map view at 45 m**



# E9608 Smallbox 4

24-Aug-96 20:05 to 25-Aug-96 11:34

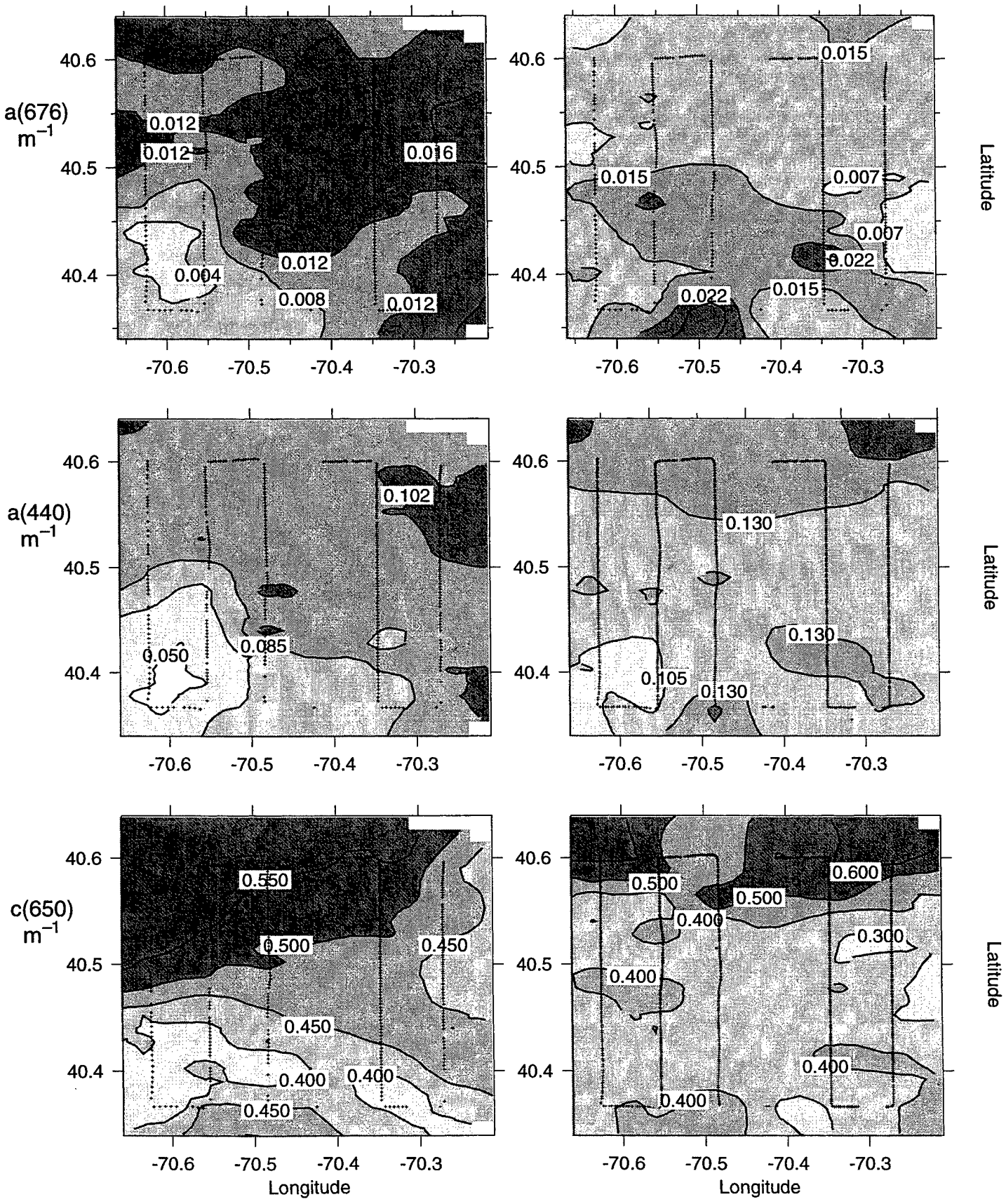
**Map view at $\sigma_t$ = 24.6 ± 0.025 kg/m$^3$** **Map view at 10 m above the bottom**



# E9608 Smallbox 5

25-Aug-96 23:15 to 26-Apr-96 01:05

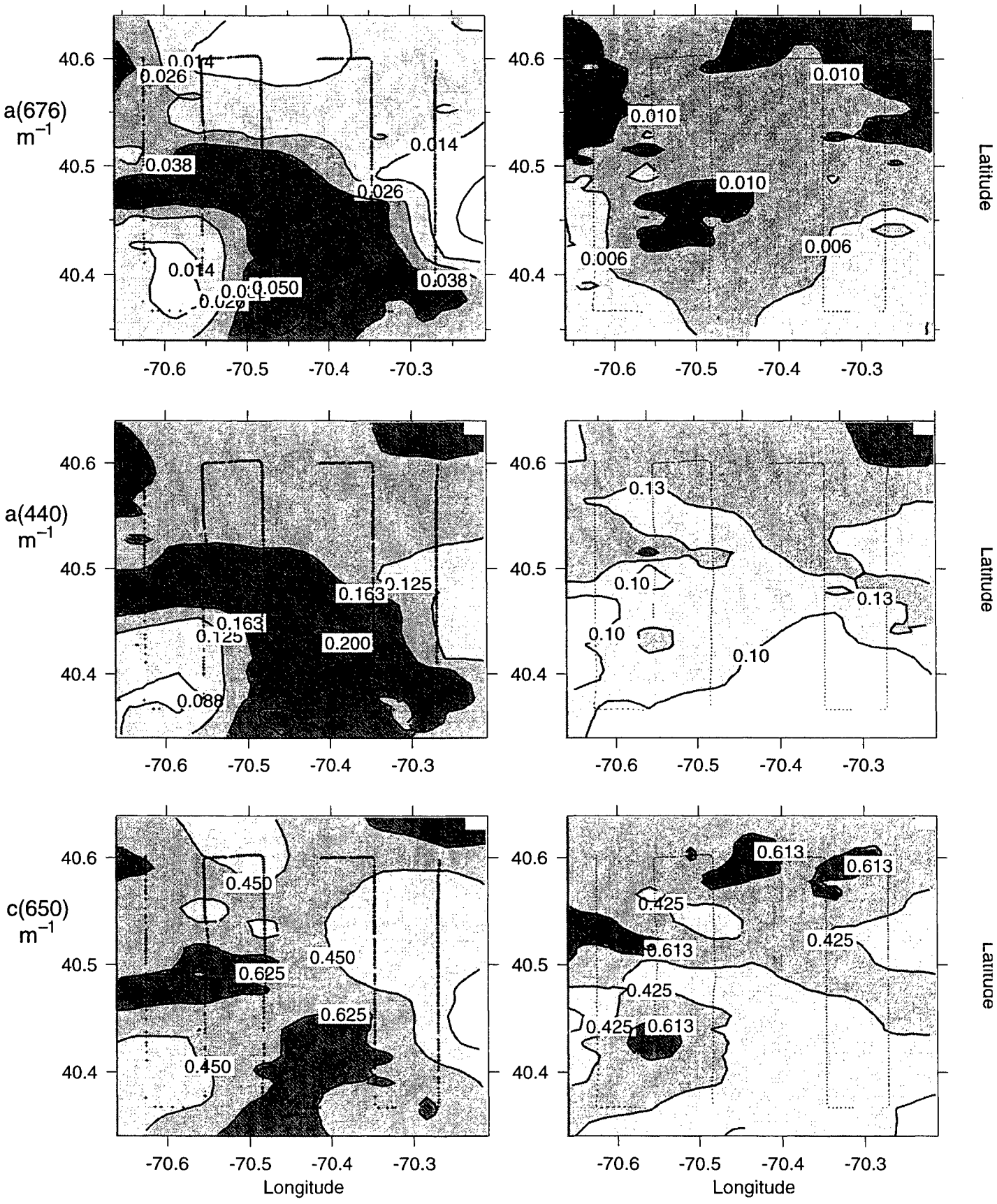
**Map view at 5 m** **Map view at 45 m**



# E9608 Smallbox 5

25-Aug-96 23:15 to 26-Aug-96 01:05

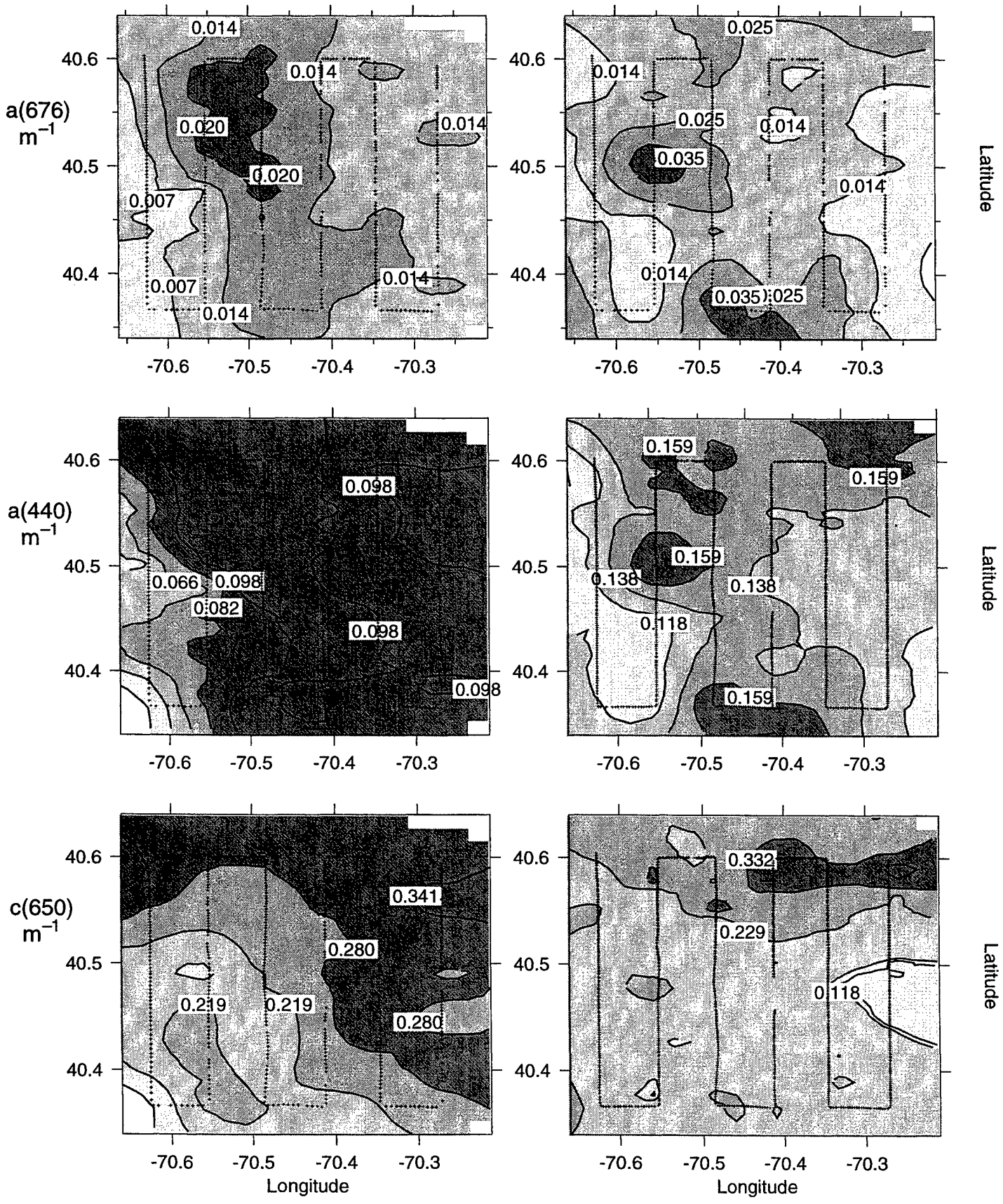
**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**



# E9608 Smallbox 6

26-Aug-96 14:48 to 26-Aug-96 04:55

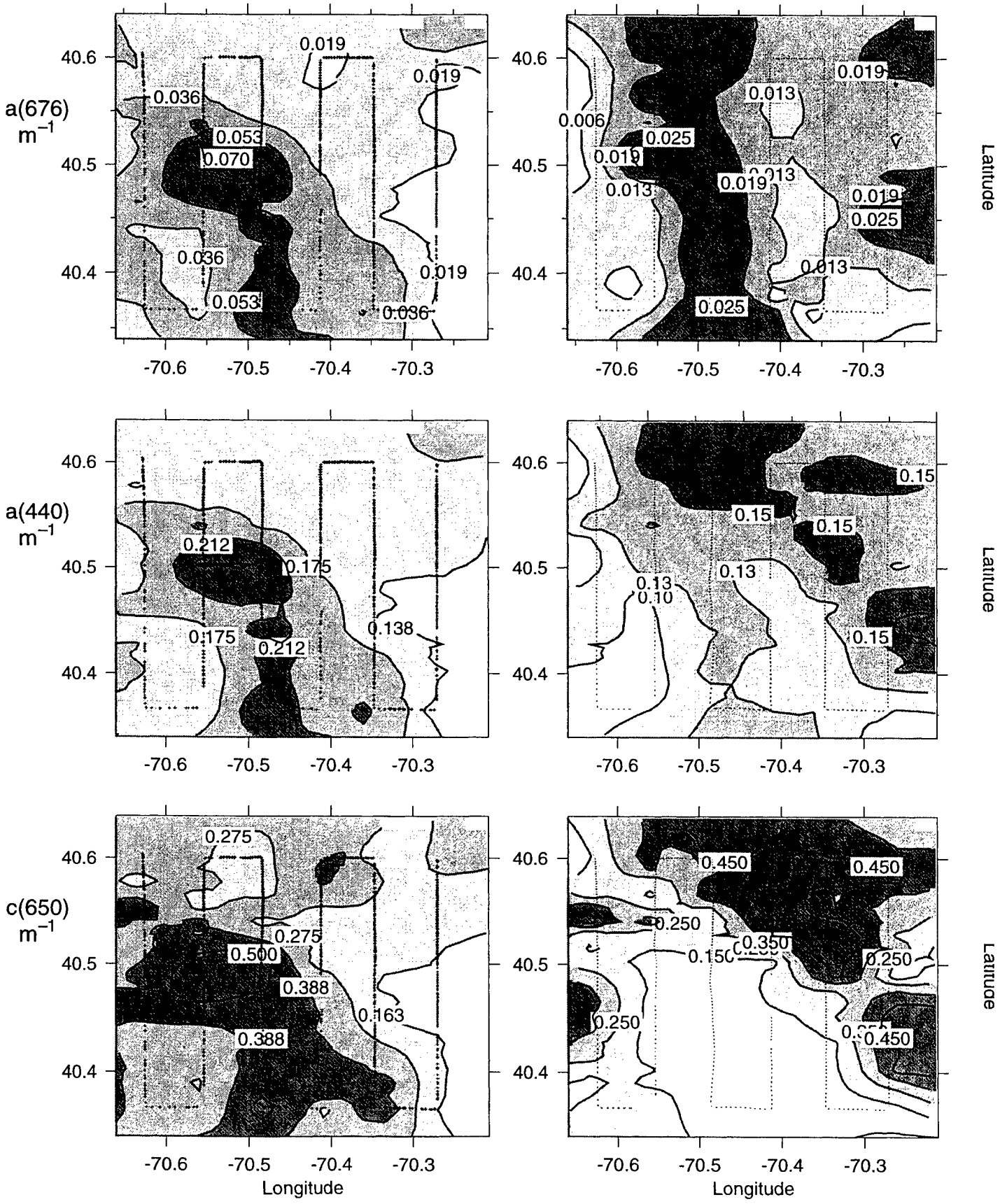
**Map view at 5 m** **Map view at 45 m**



# E9608 Smallbox 6

26-Aug-96 03:11 to 26-Aug-96 16:52

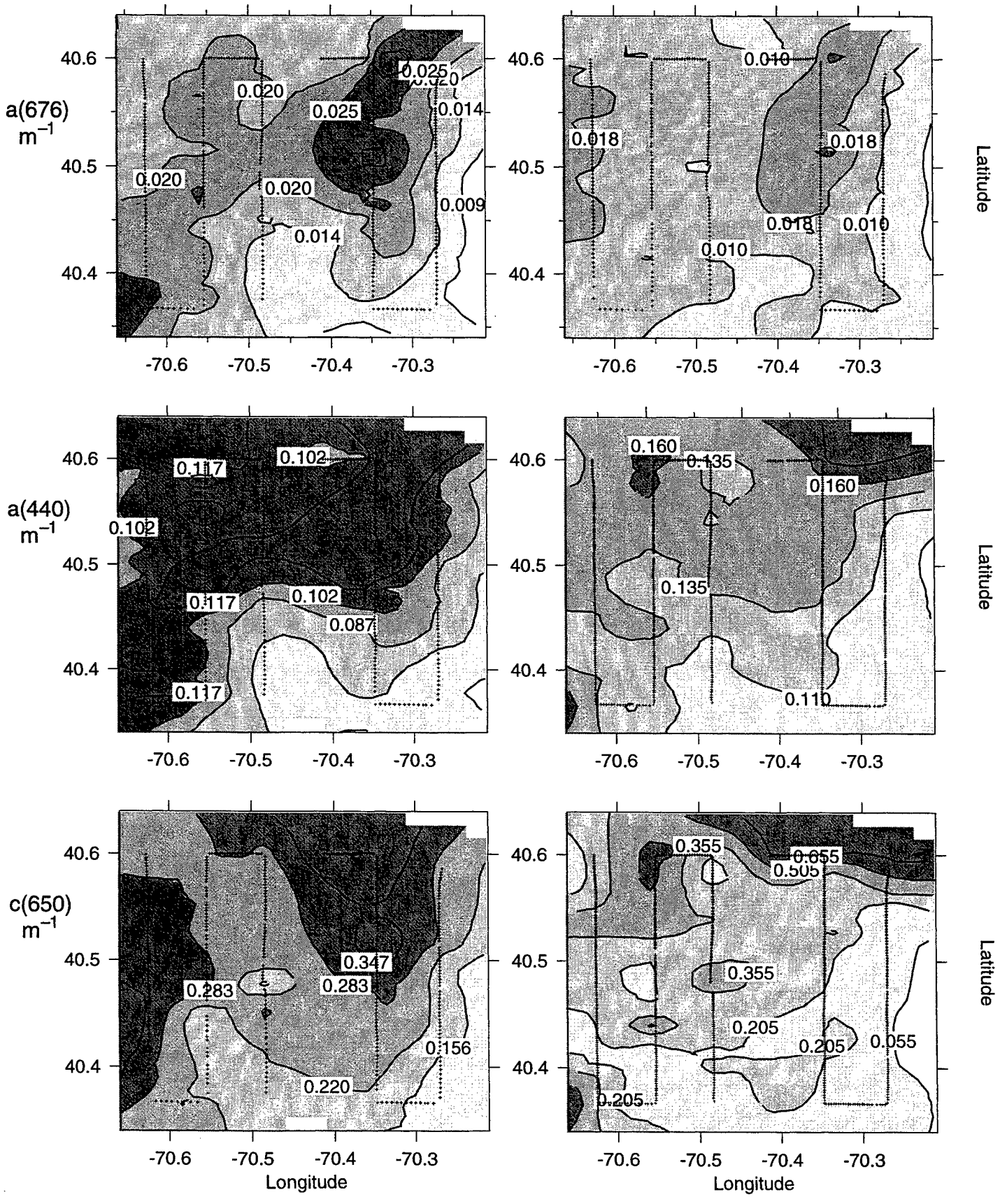
**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**



# E9608 Smallbox 7

29-Aug-96 05:52 to 29-Aug-96 16:42

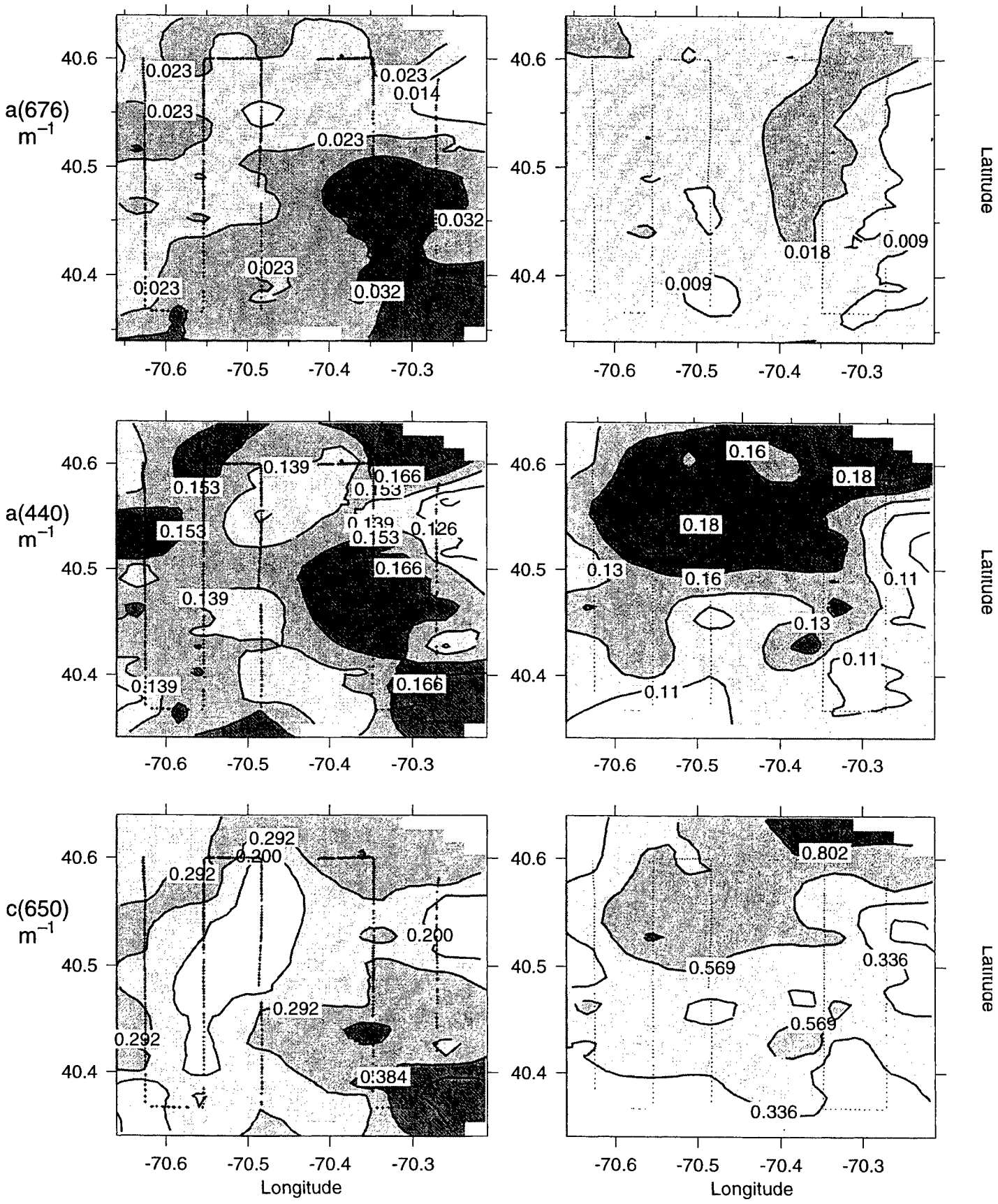
**Map view at 5 m** **Map view at 45 m**



# E9608 Smallbox 7

29-Aug-96 04:00 to 29-Aug-96 18:50

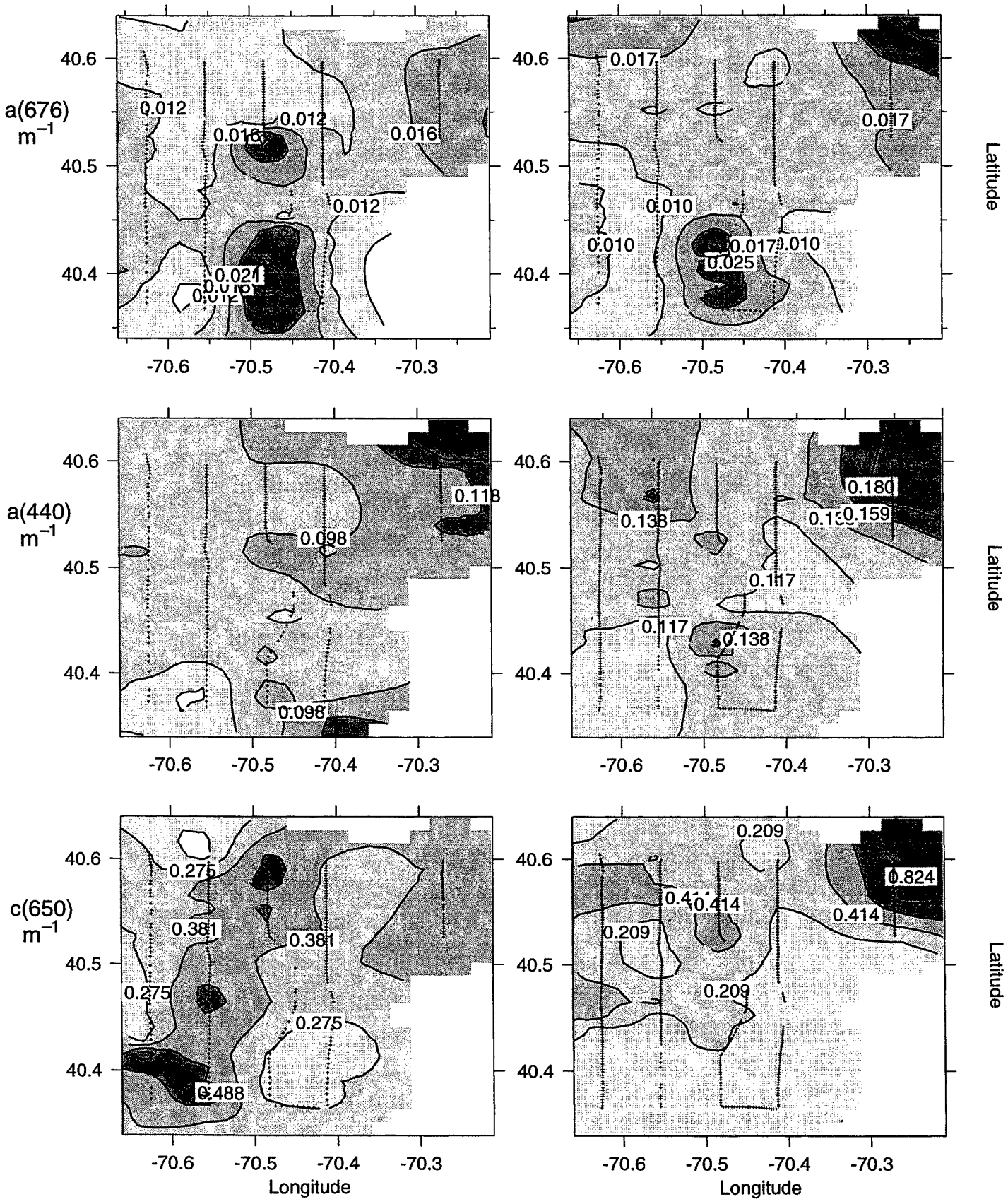
**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**



# E9608 Smallbox 8

30-Aug-96 10:07 to 29-Aug-96 21:55

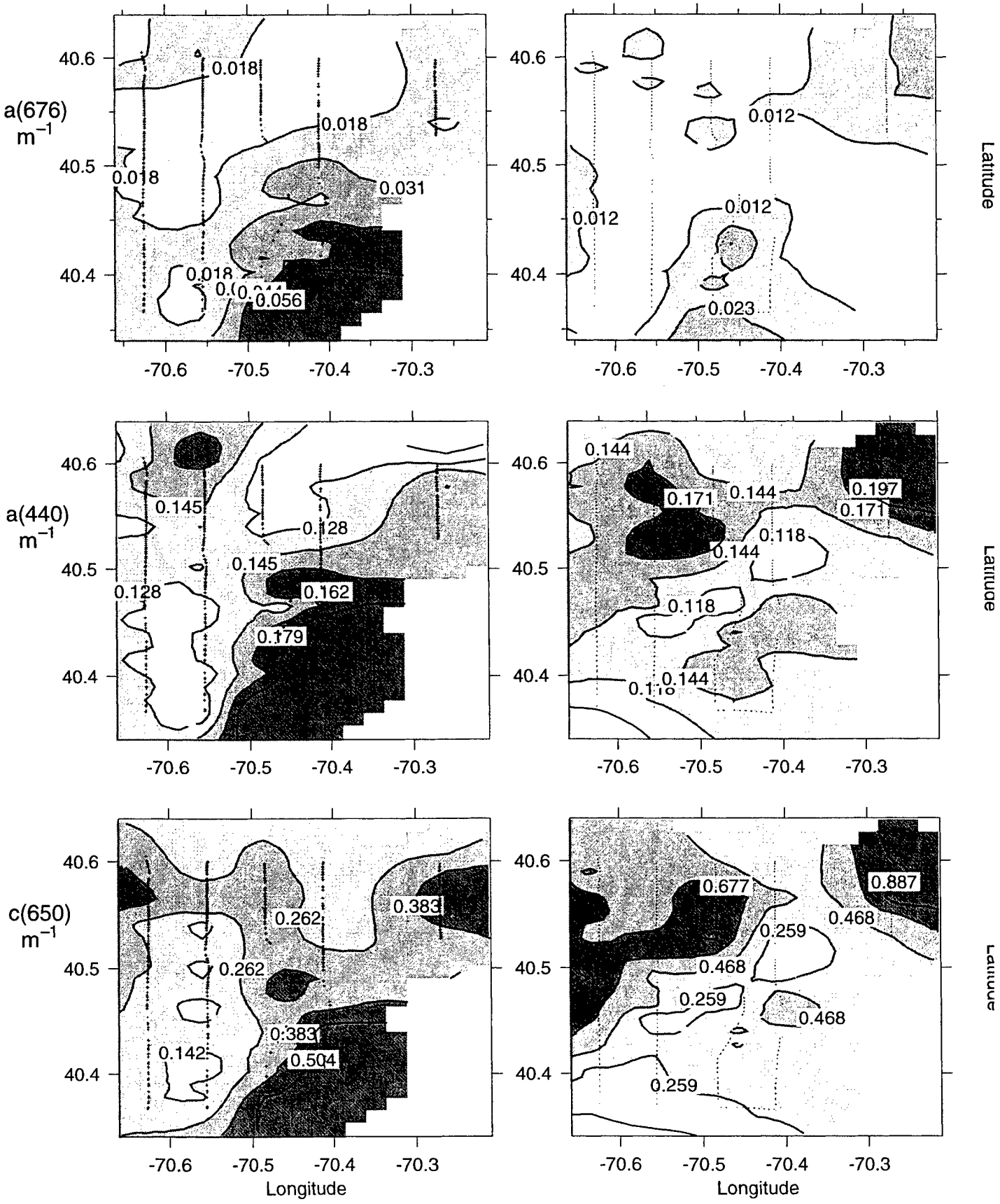
**Map view at 5 m** **Map view at 45 m**



# E9608 Smallbox 8

30-Aug-96 10:07 to 30-Aug-96 12:10

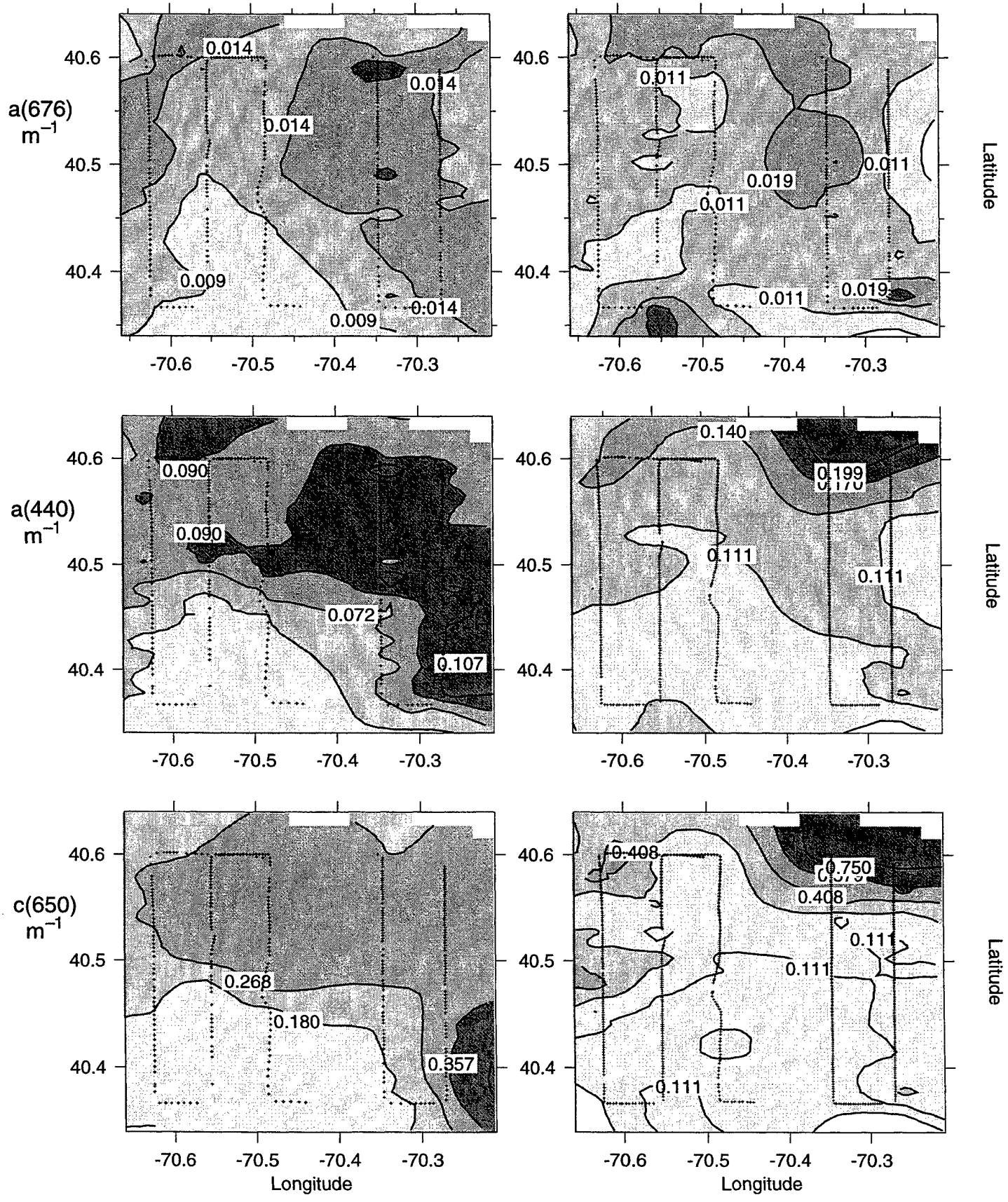
**Map view at $\sigma_t$ = 24.6 ± 0.025 kg/m$^3$** **Map view at 10 m above the bottom**



# E9608 Smallbox 9

31-Aug-96 02:58 to 31-Aug-96 05:48

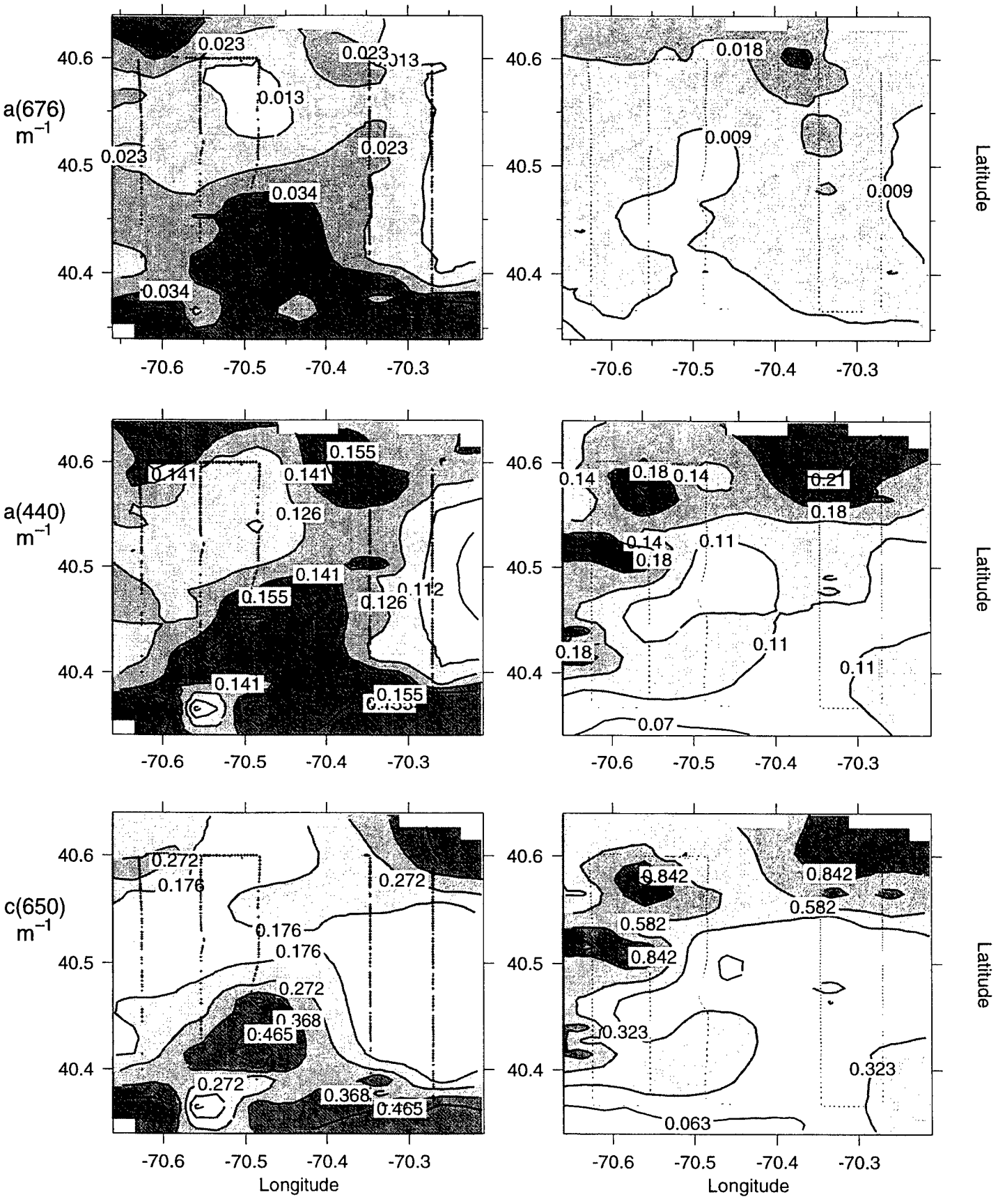
**Map view at 5 m** **Map view at 45 m**



# E9608 Smallbox 9

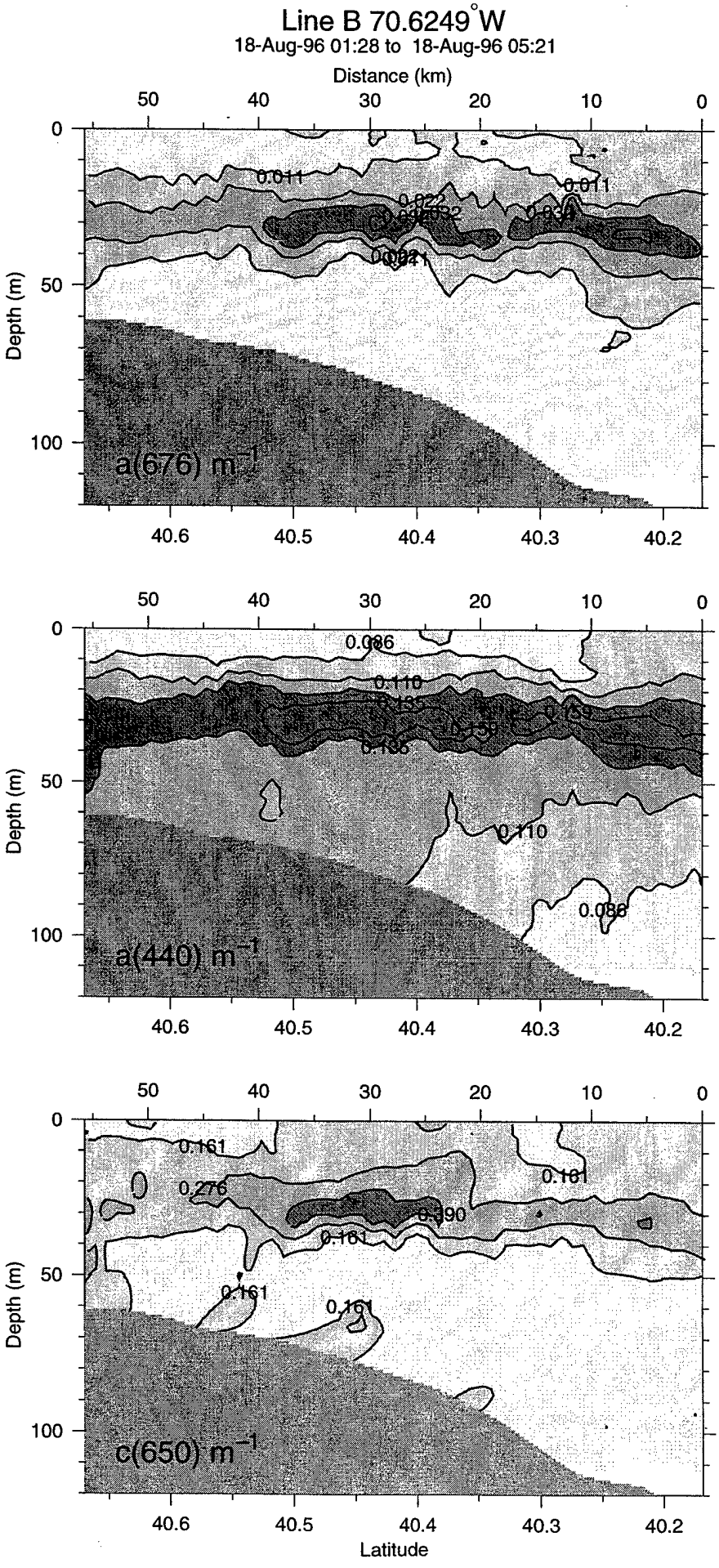
30-Aug-96 14:52 to 31-Aug-96 05:48

**Map view at $\sigma_t = 24.6 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**

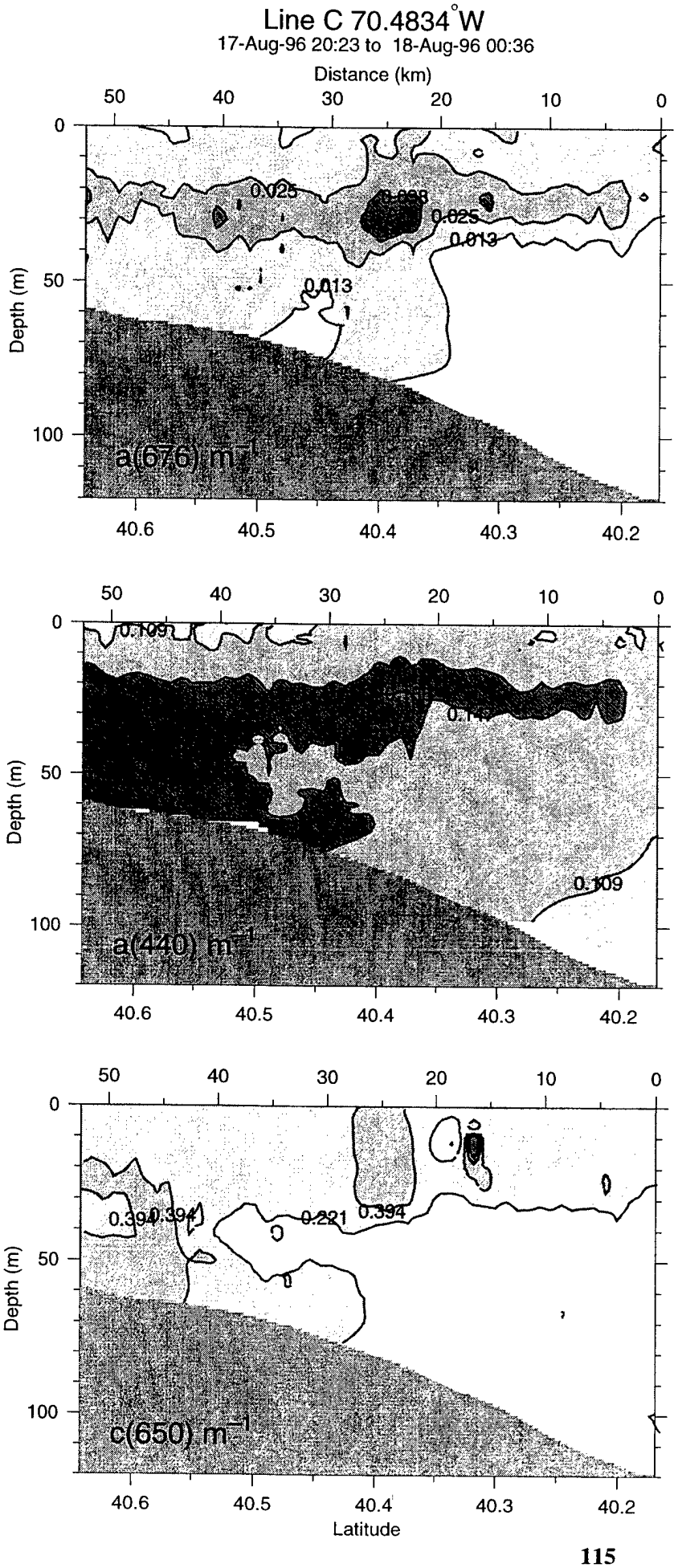


# E9608 Bigbox Sections

# E9608 Bigbox 1



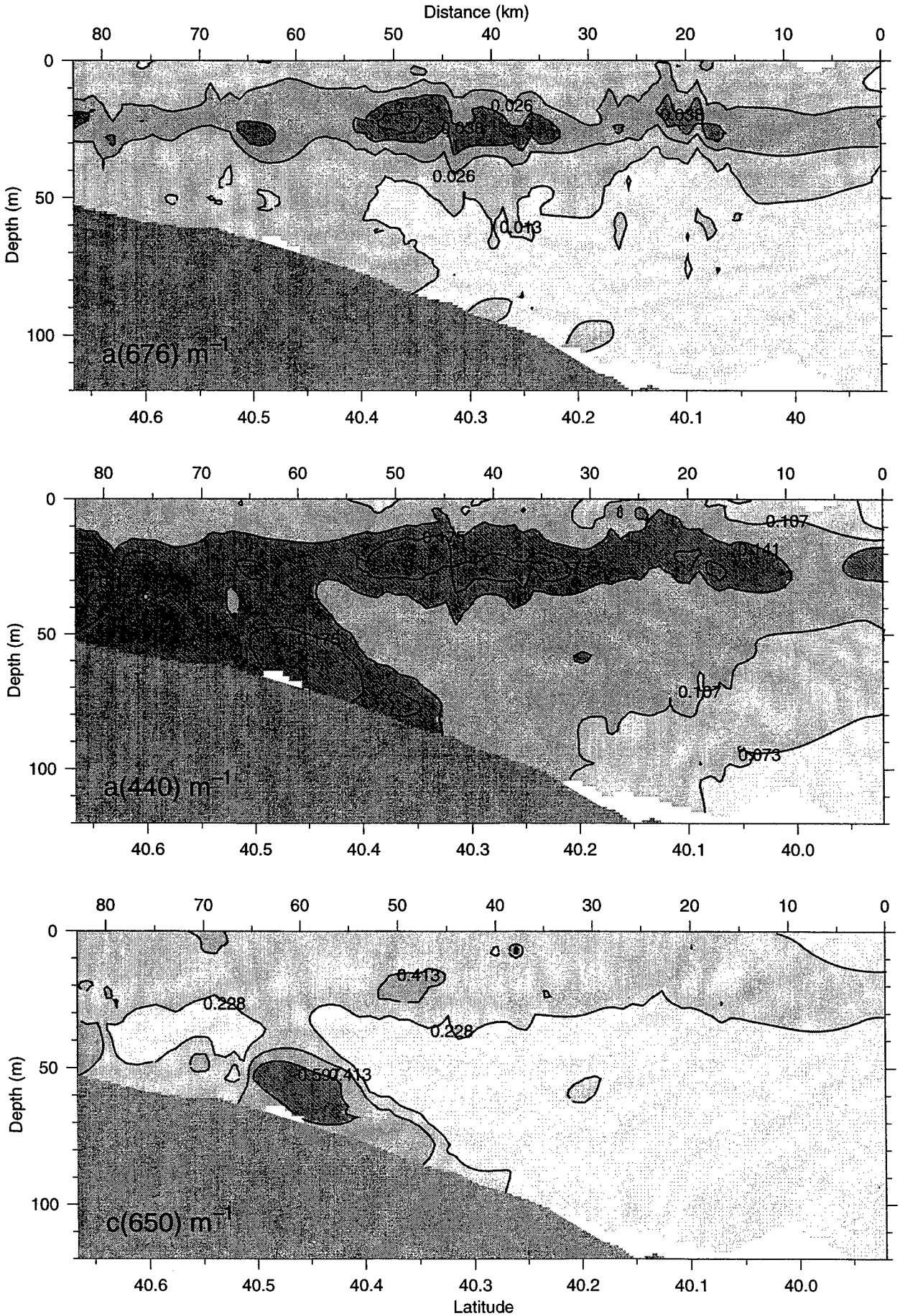
# E9608 Bigbox 1



# E9608 Bigbox 1

## Line D 70.3466°W

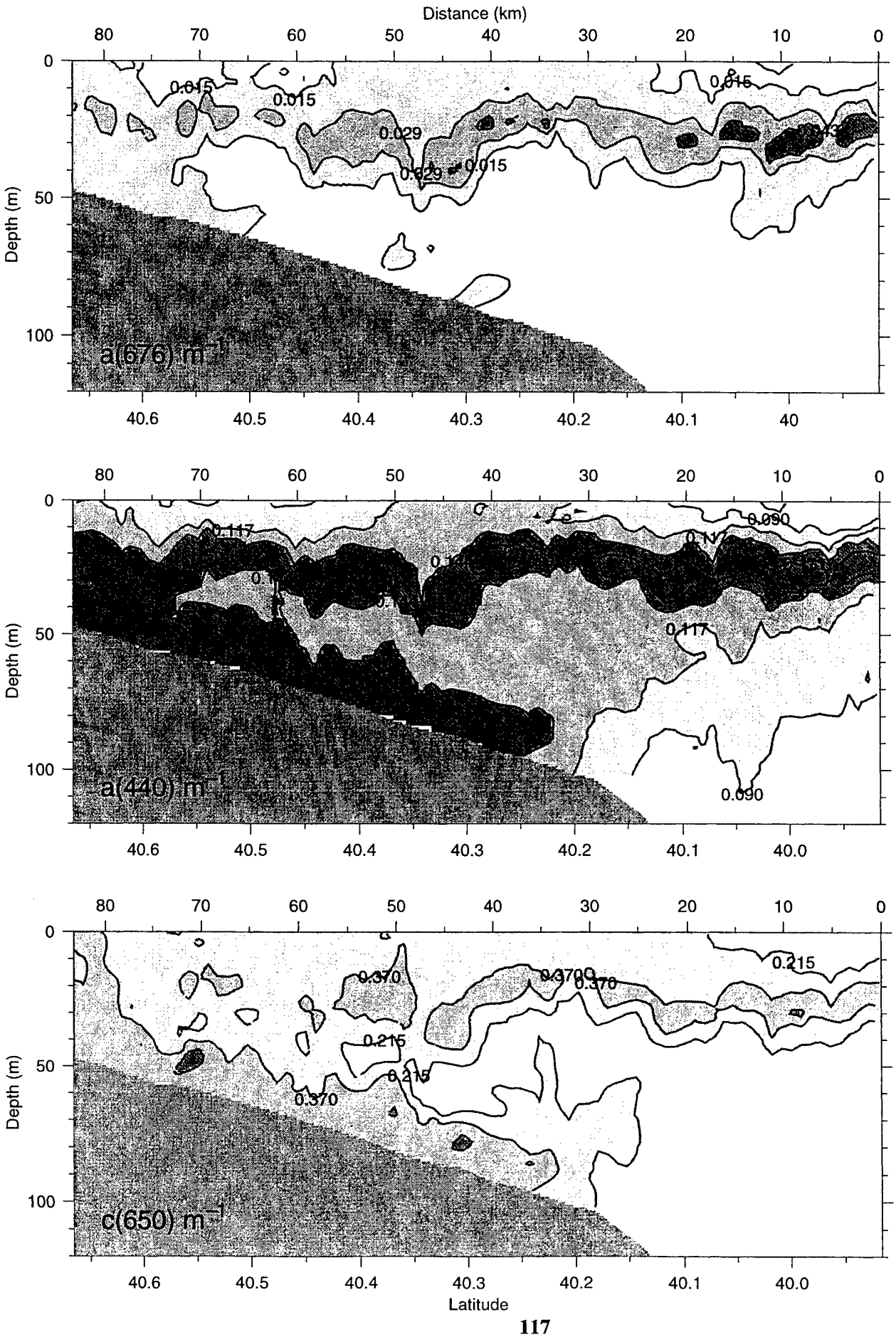
17-Aug-96 13:43 to 17-Aug-96 19:24



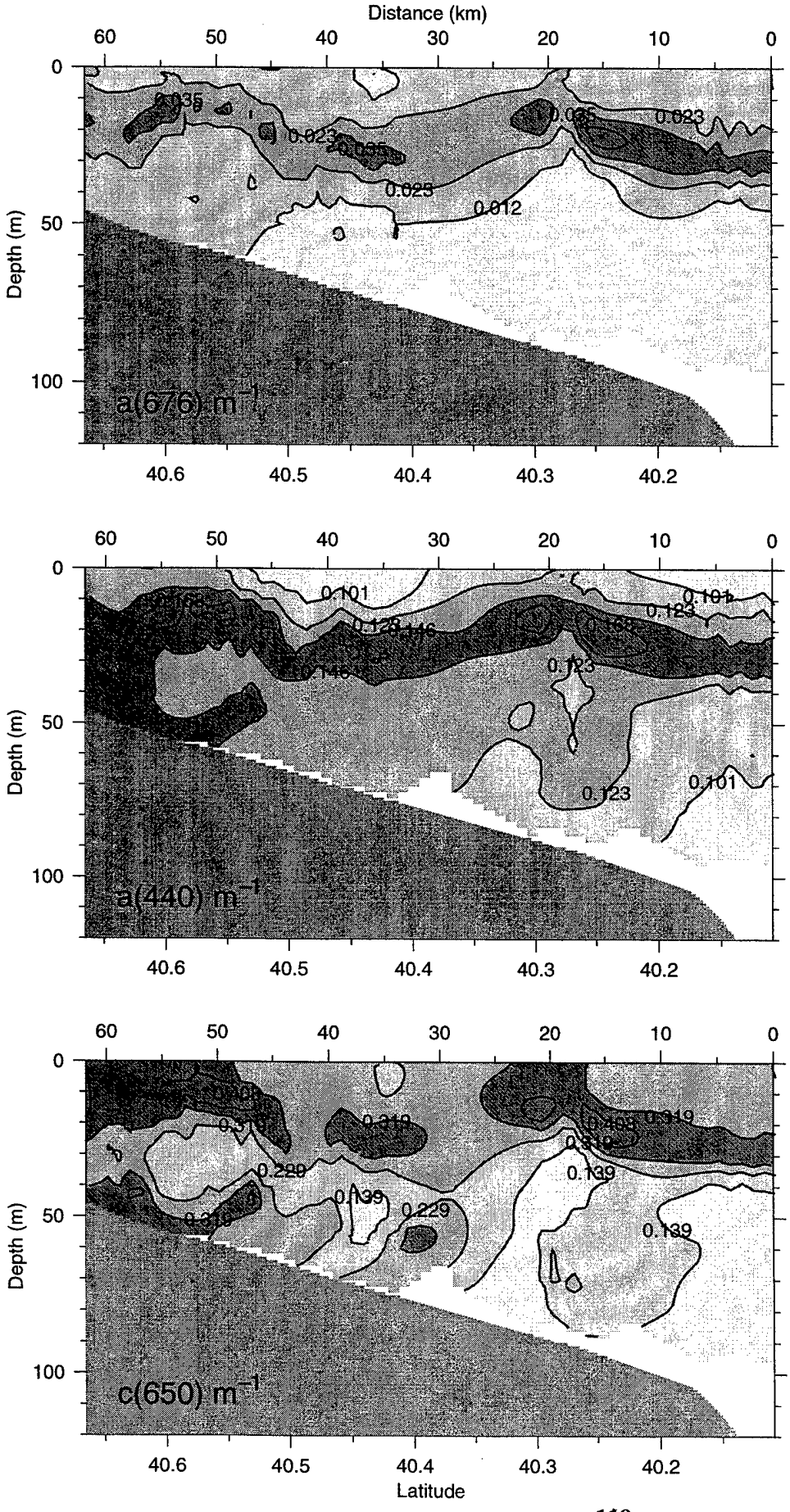
# E9608 Bigbox 1

Line E 70.2002°W

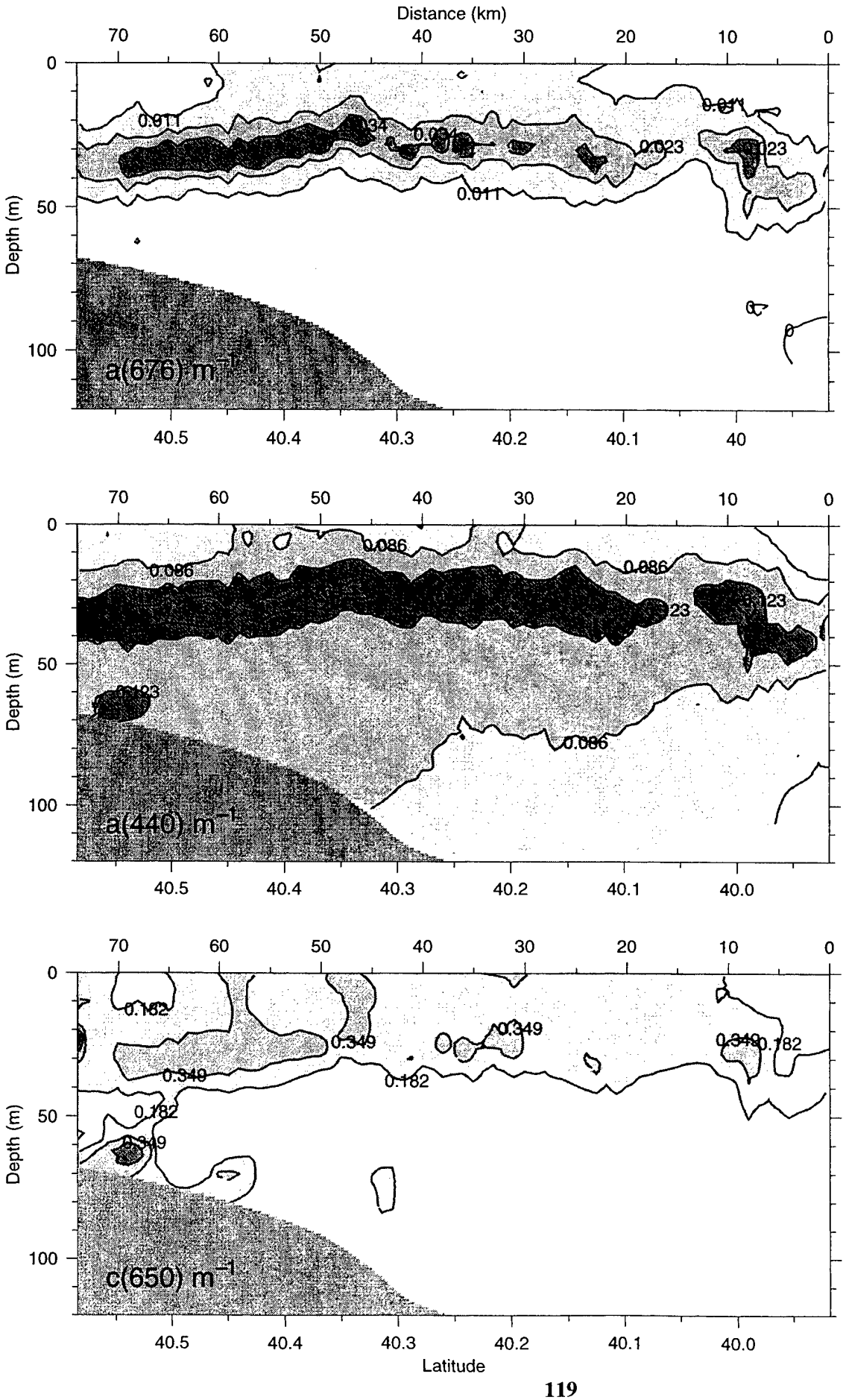
17-Aug-96 07:00 to 17-Aug-96 12:39



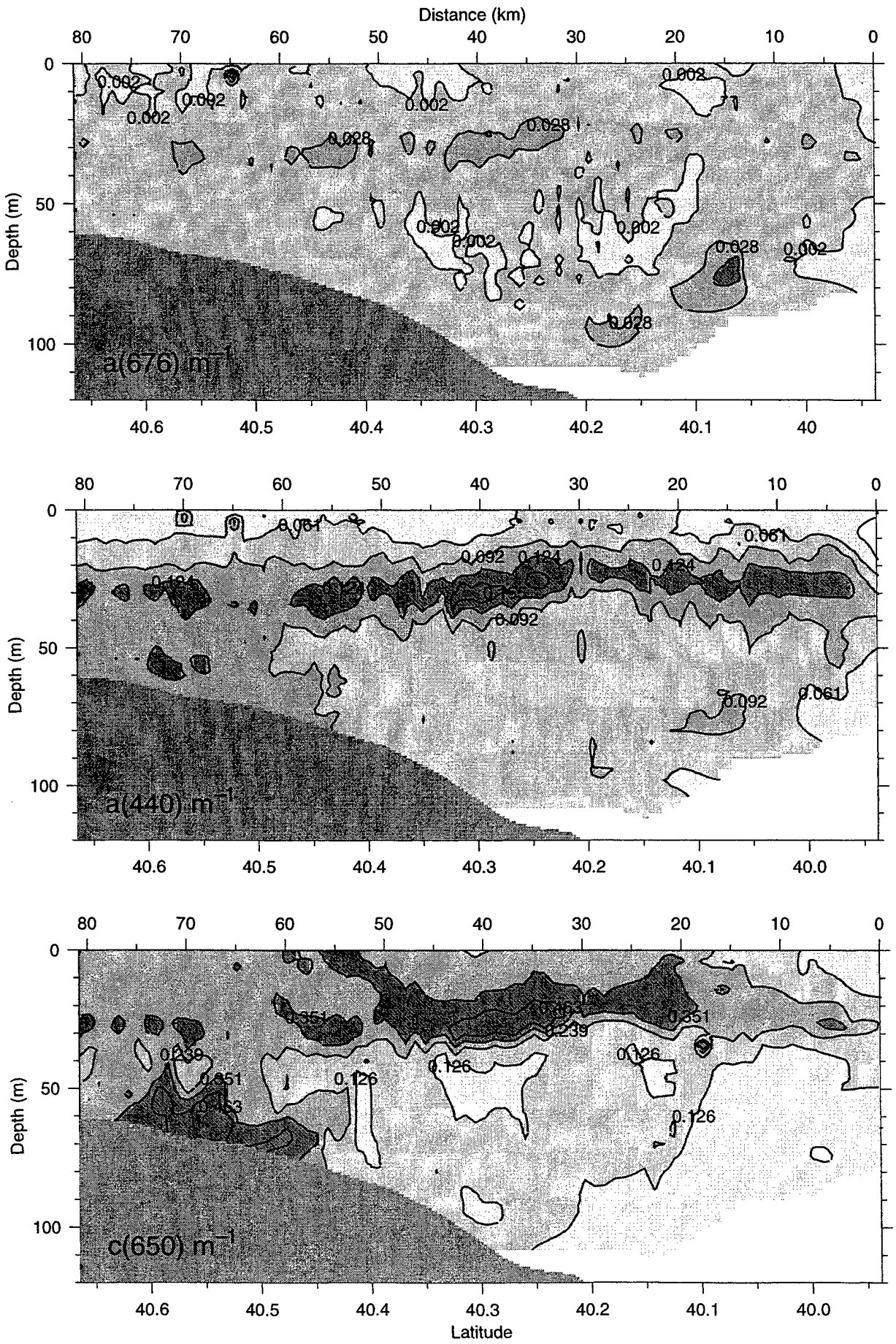
# E9608 Bigbox 1



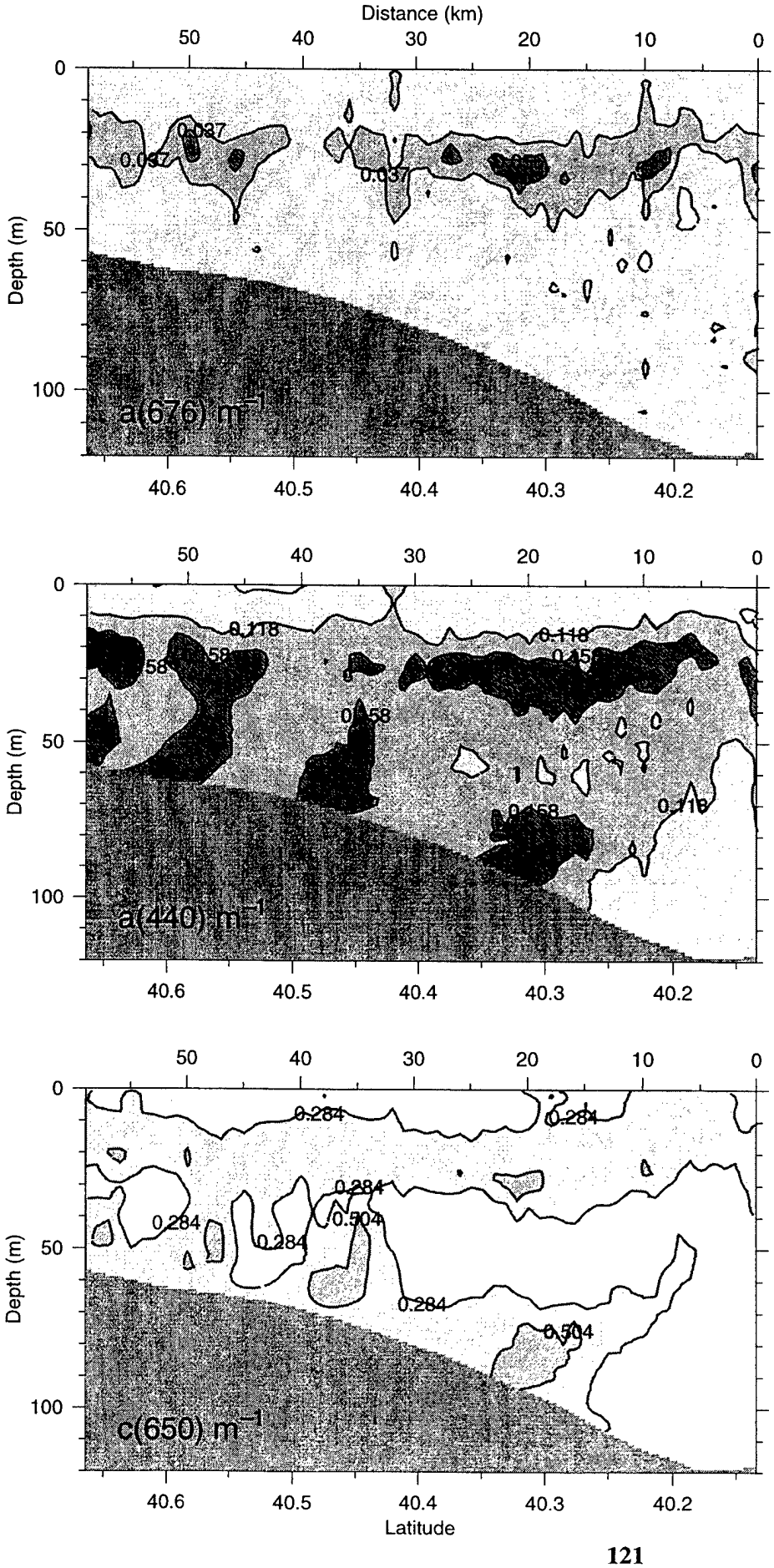
# E9608 Bigbox 2



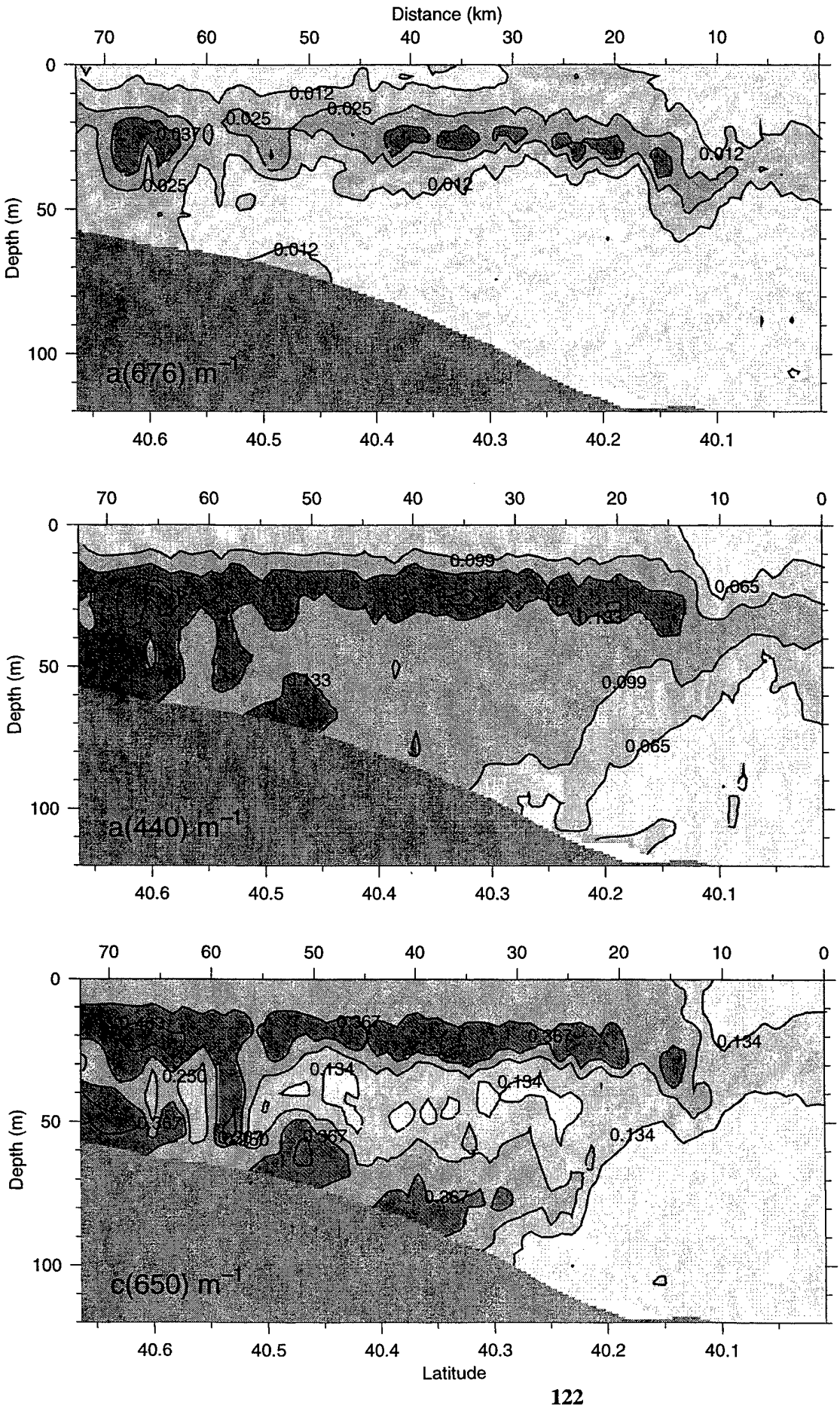
# E9608 Bigbox 2



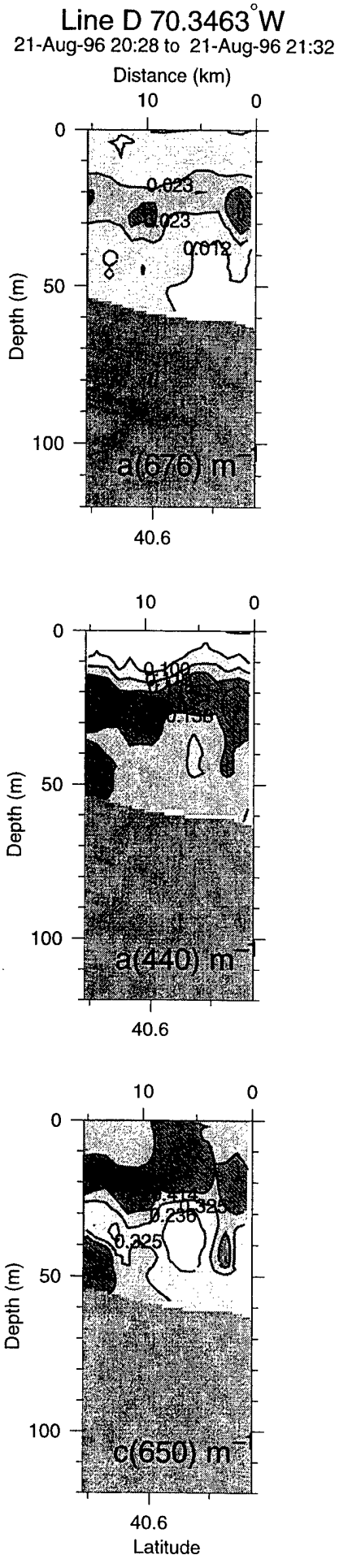
# E9608 Bigbox 2



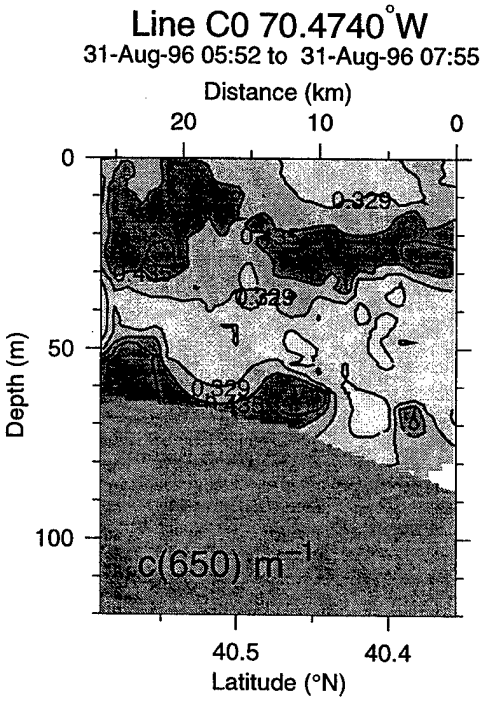
# E9608 Bigbox 2



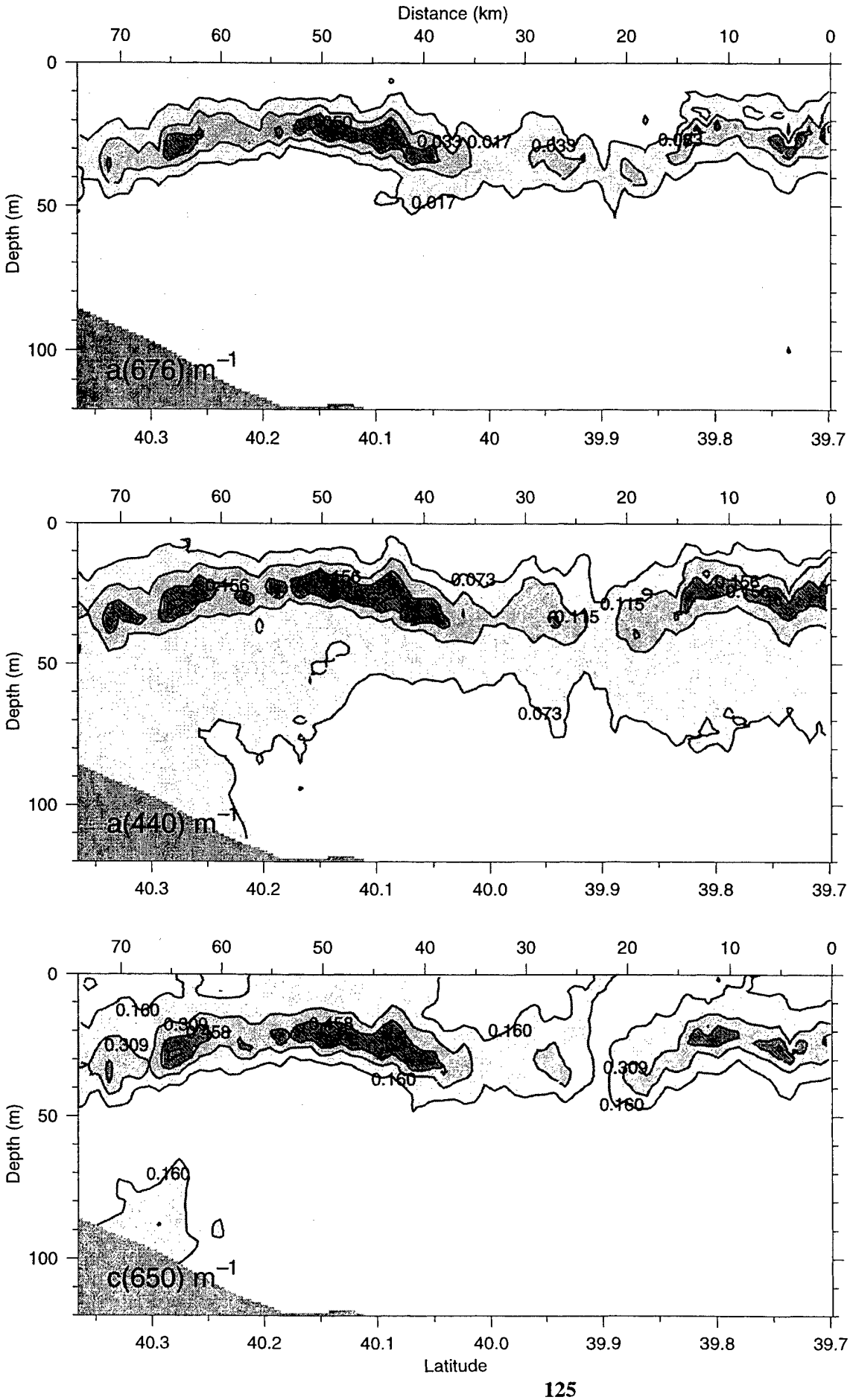
# E9608 Bigbox 2



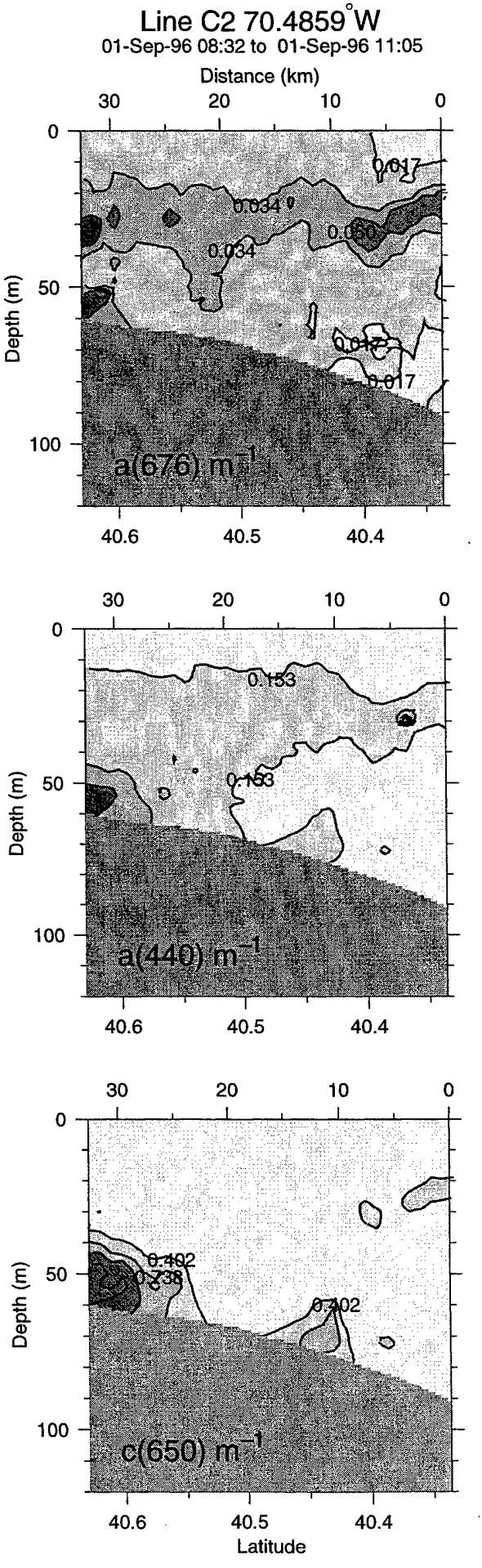
# E9608 Bigbox 3



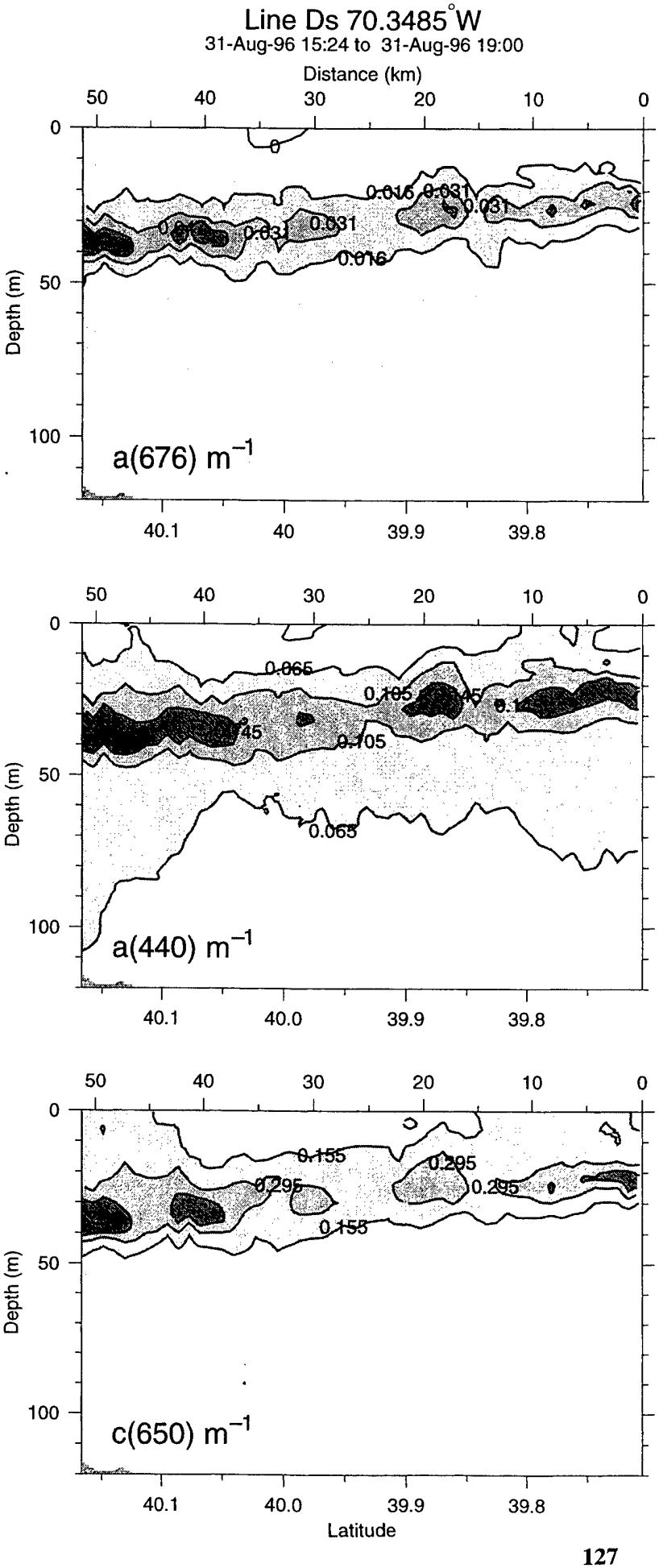
# E9608 Bigbox 3



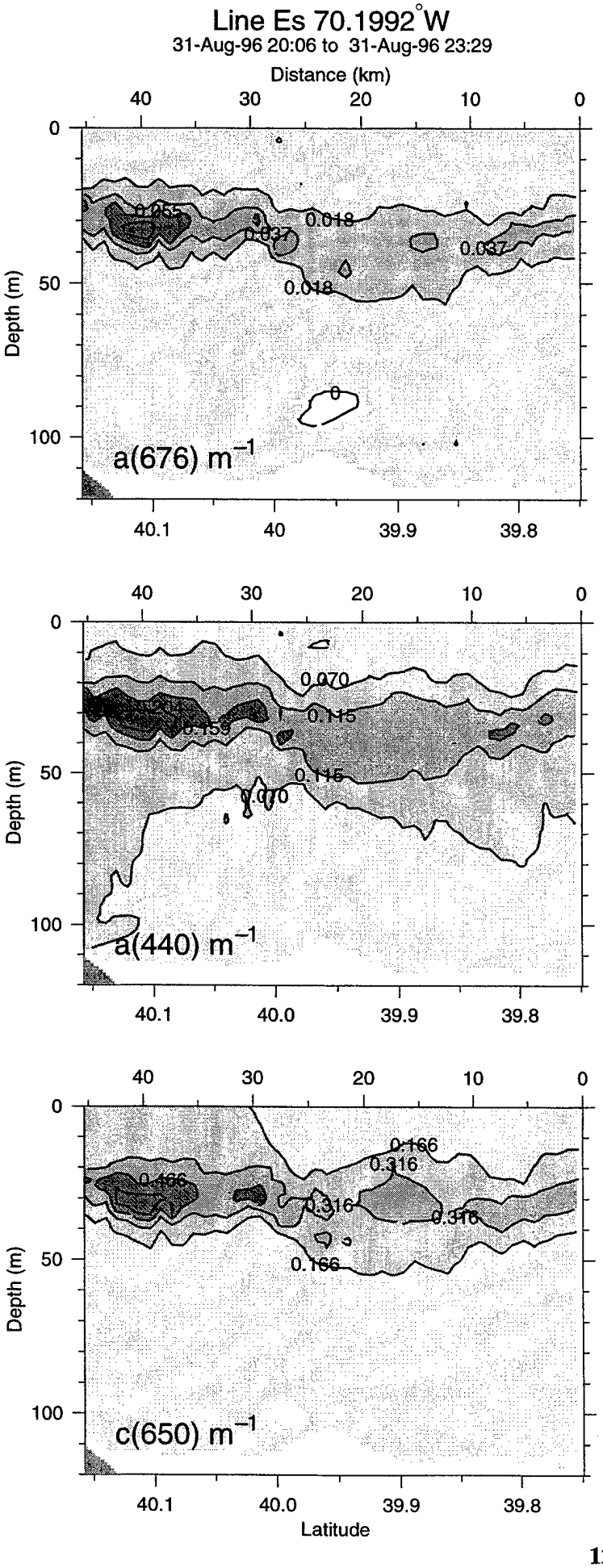
# E9608 Bigbox 3



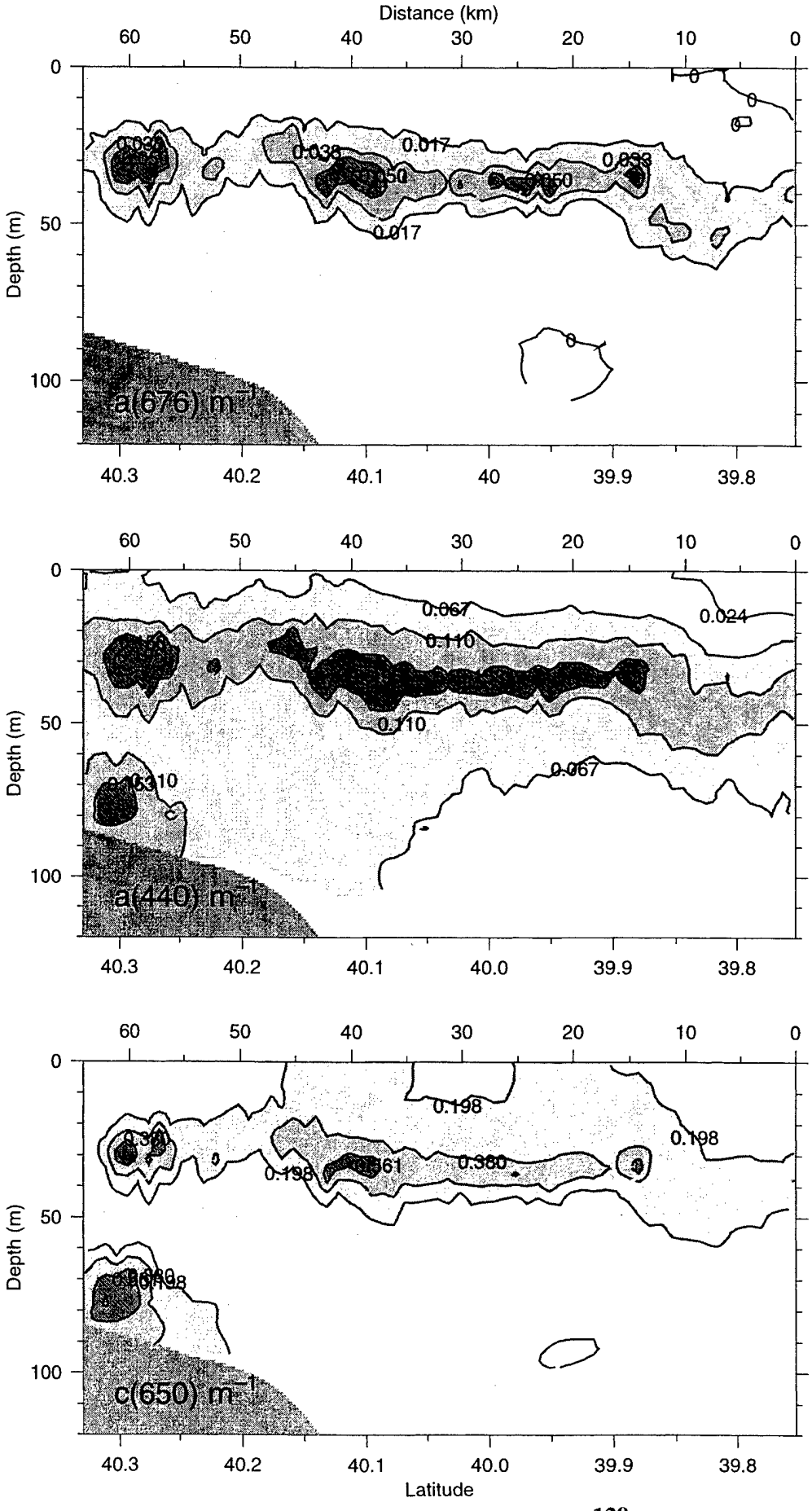
# E9608 Bigbox 3



# E9608 Bigbox 3

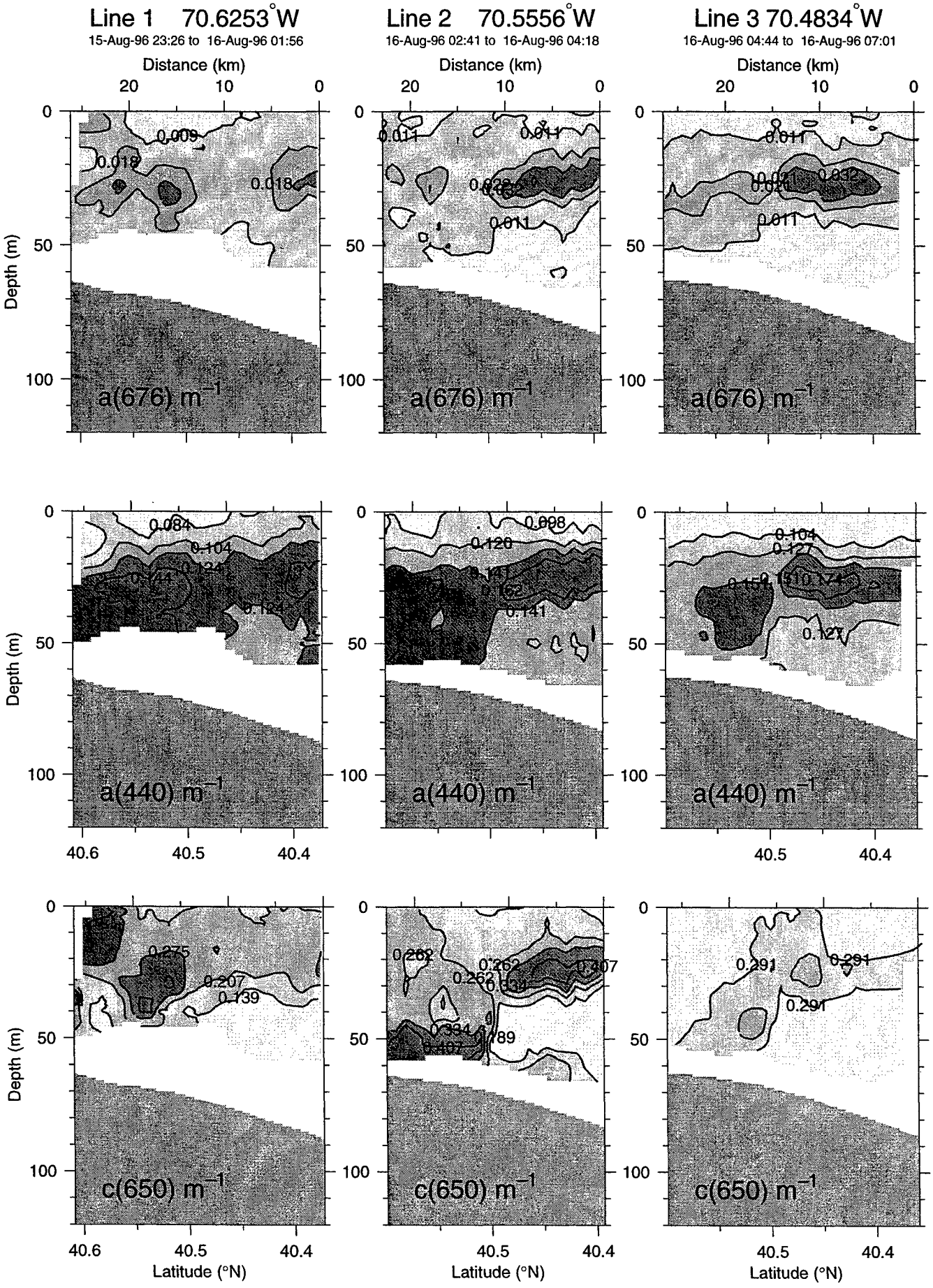


# E9608 Bigbox 3

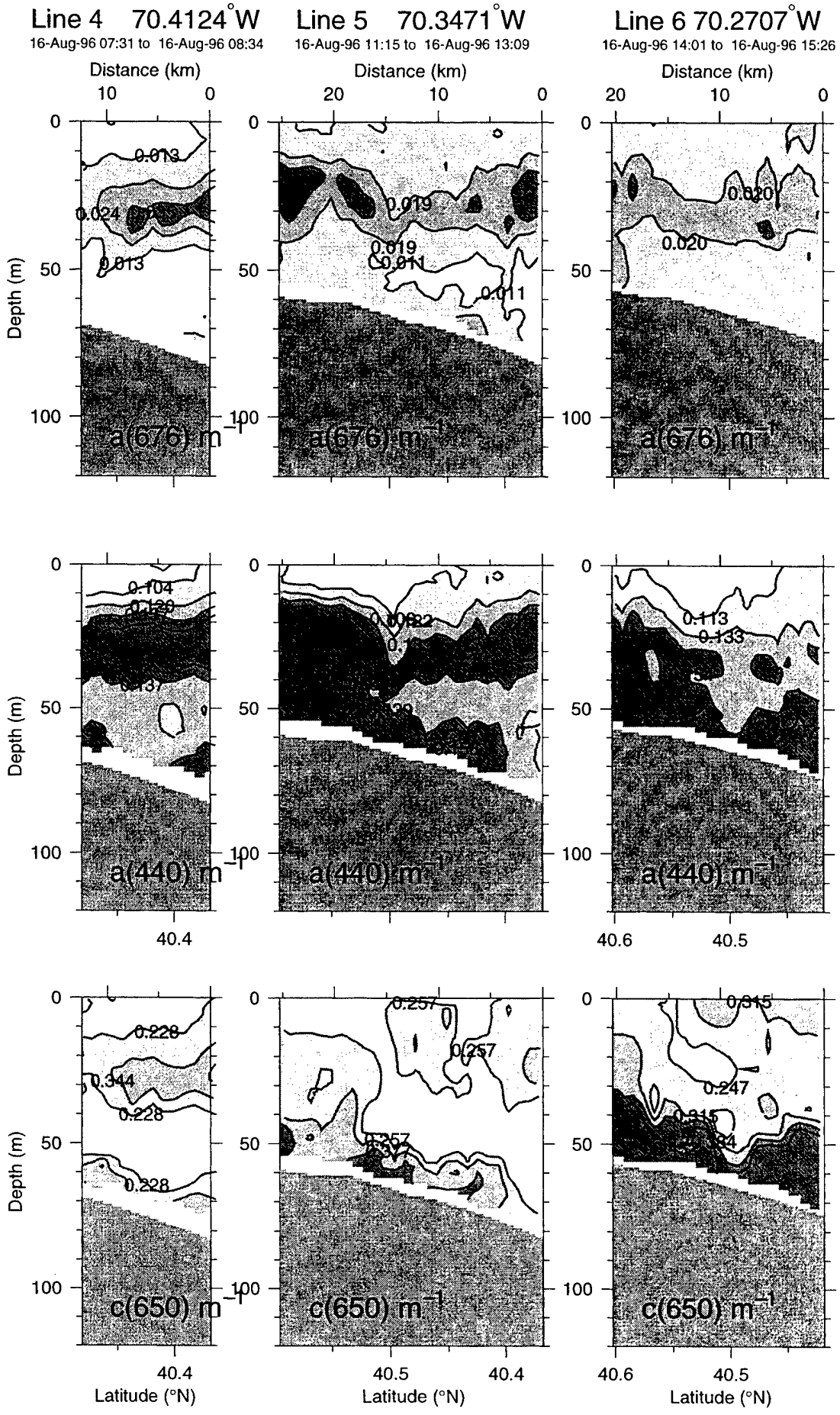


# E9608 Smallbox Sections

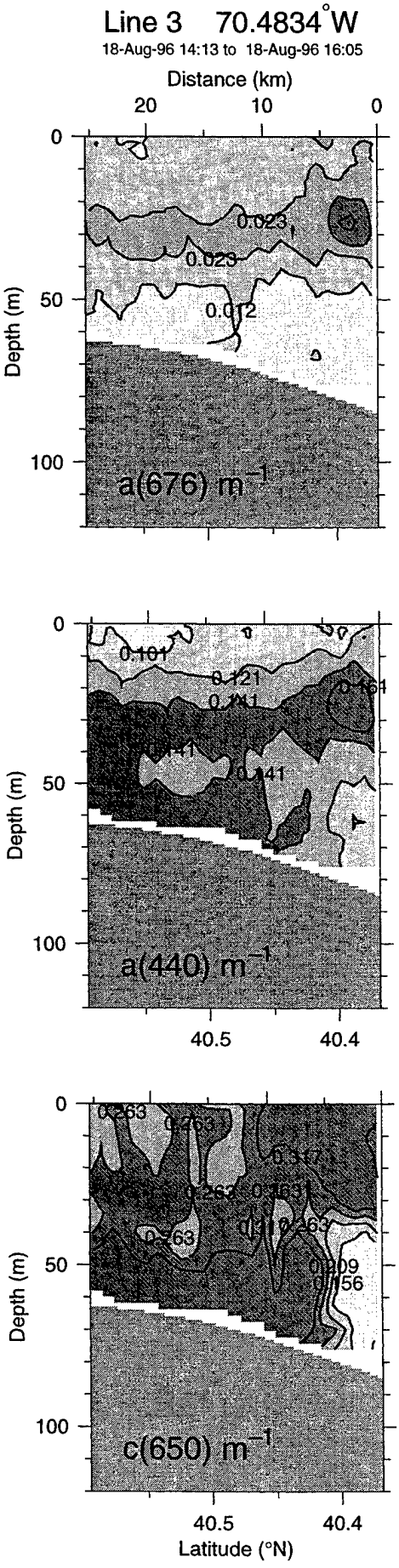
# E9608 Smallbox 1



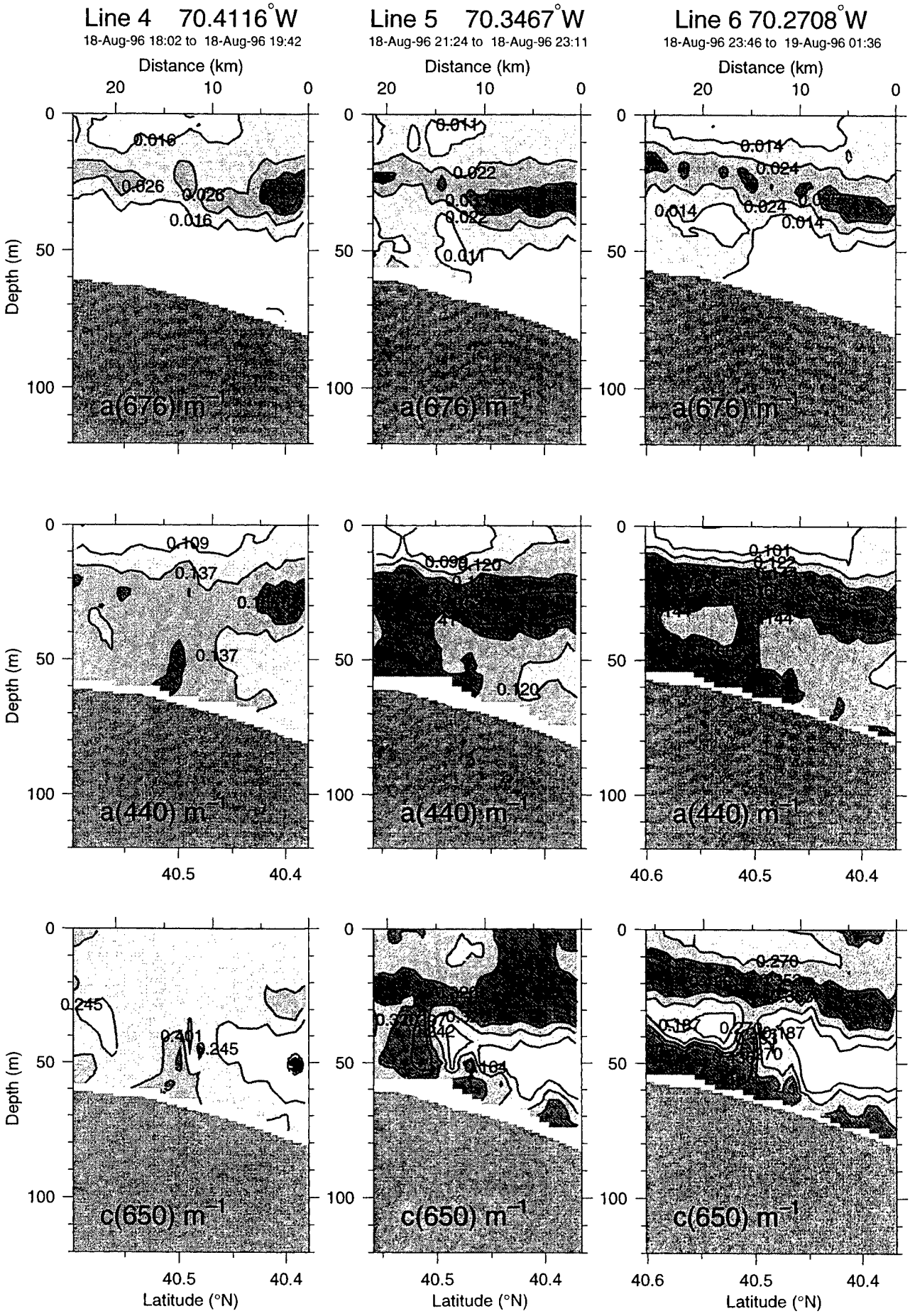
# E9608 Smallbox 1



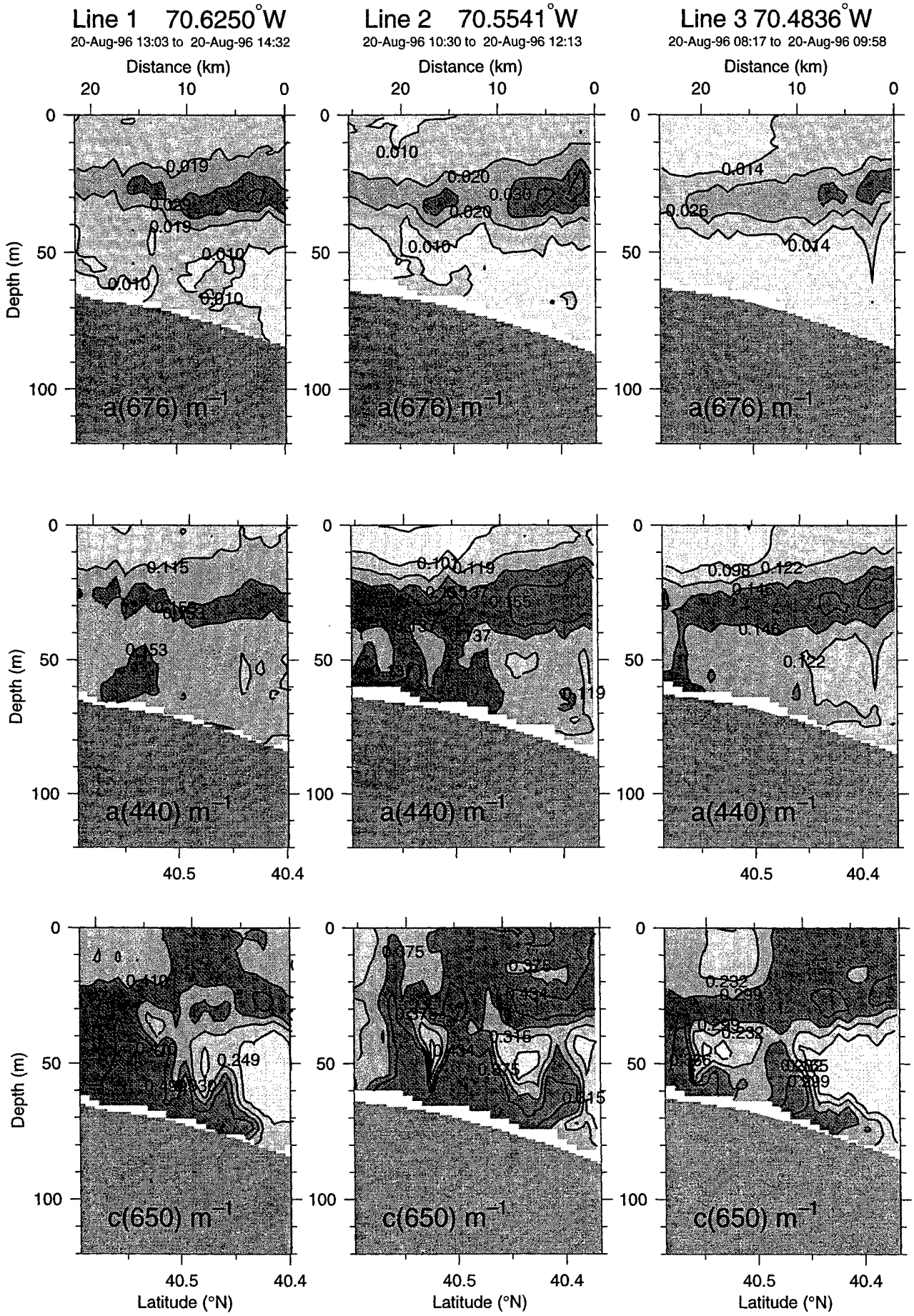
# E9608 Smallbox 2


Line 3 70.4834°W
18-Aug-96 14:13 to 18-Aug-96 16:05
Distance (km)
20
10
0
Depth (m)
0
50
100
0.023
0.023
0.012
a(676) m⁻¹
0.101
0.121
0.141
0.141
0.141
a(440) m⁻¹
40.5
40.4
0.263
0.263
0.263

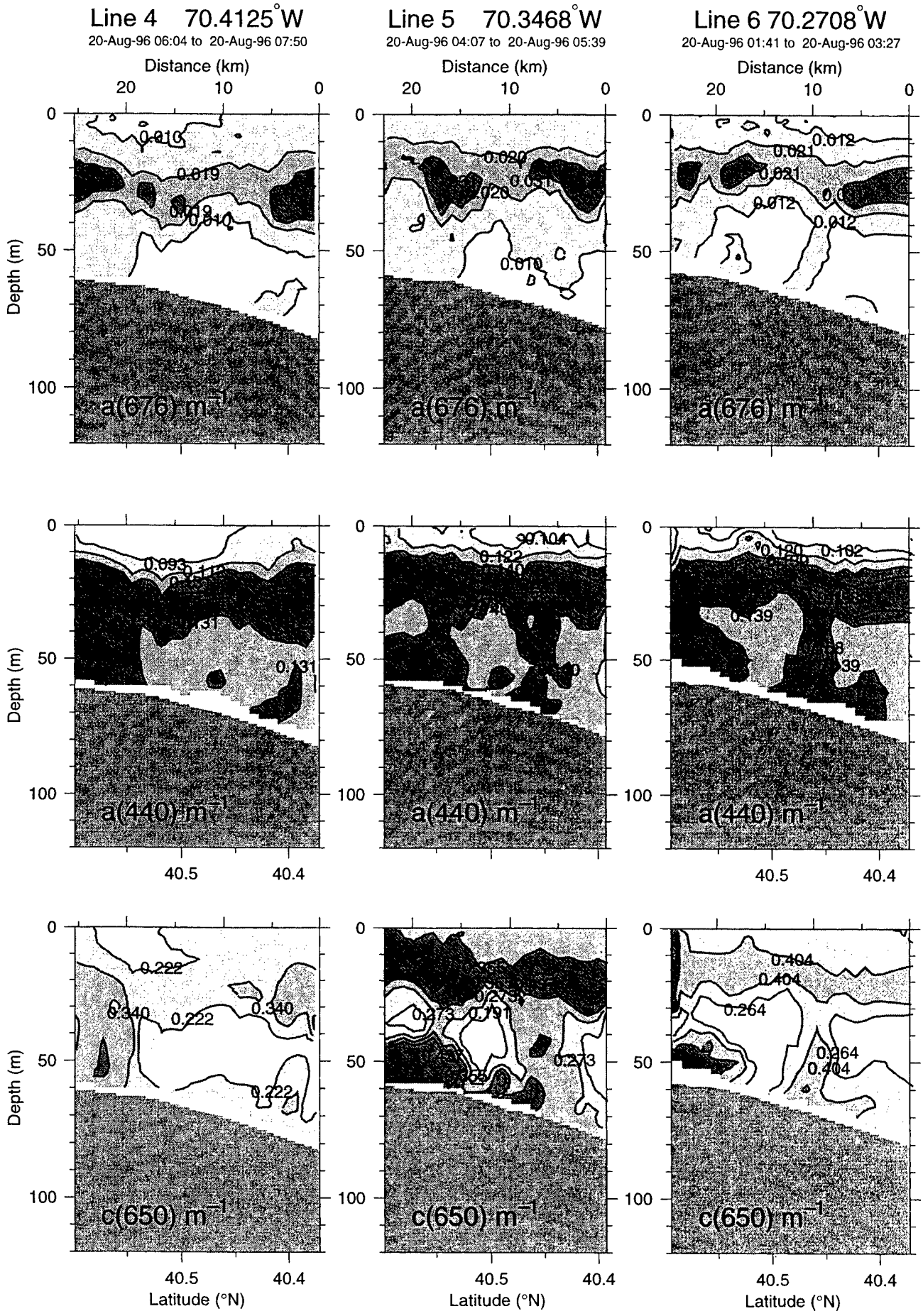
# E9608 Smallbox 2



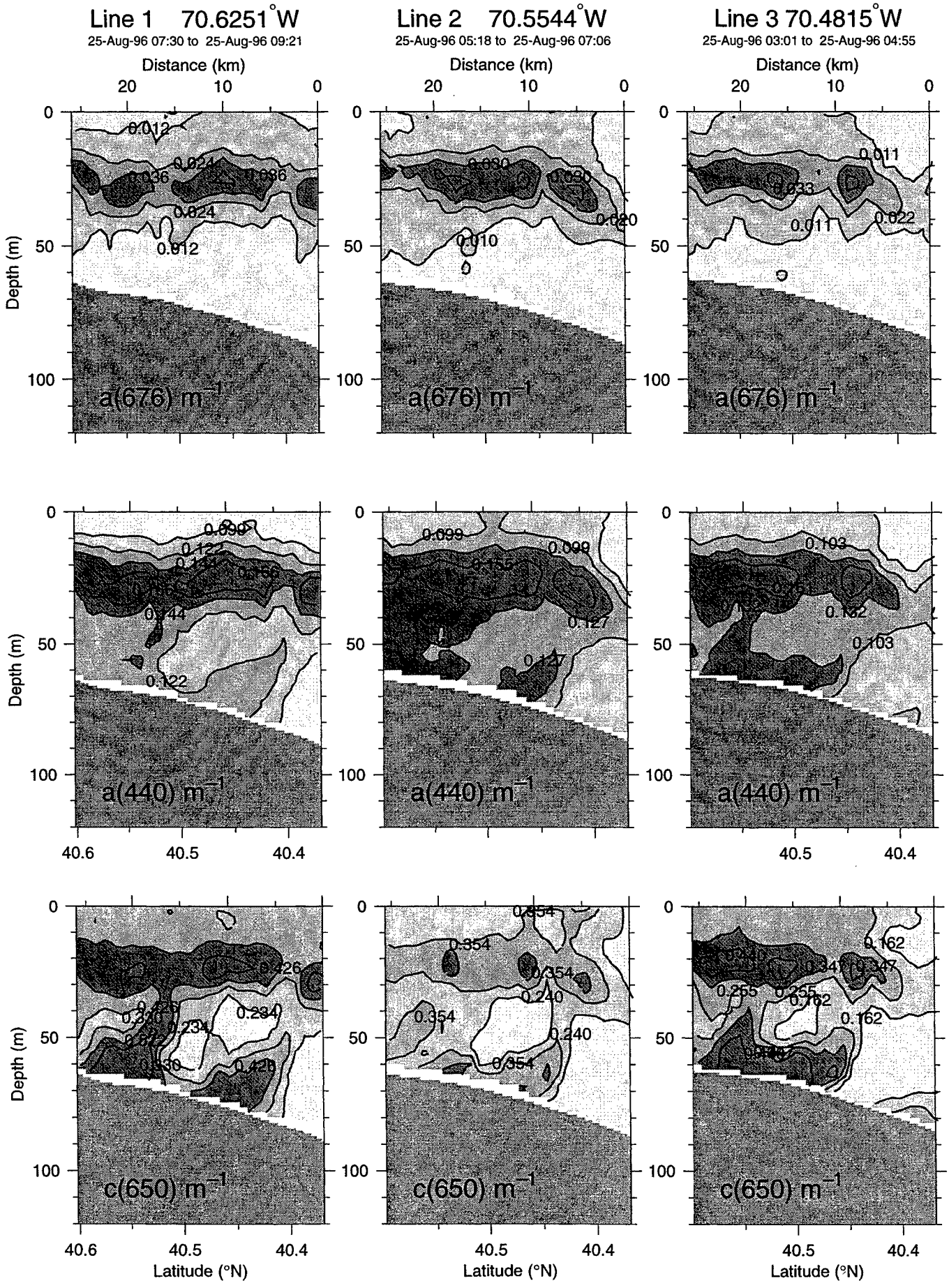
# E9608 Smallbox 3



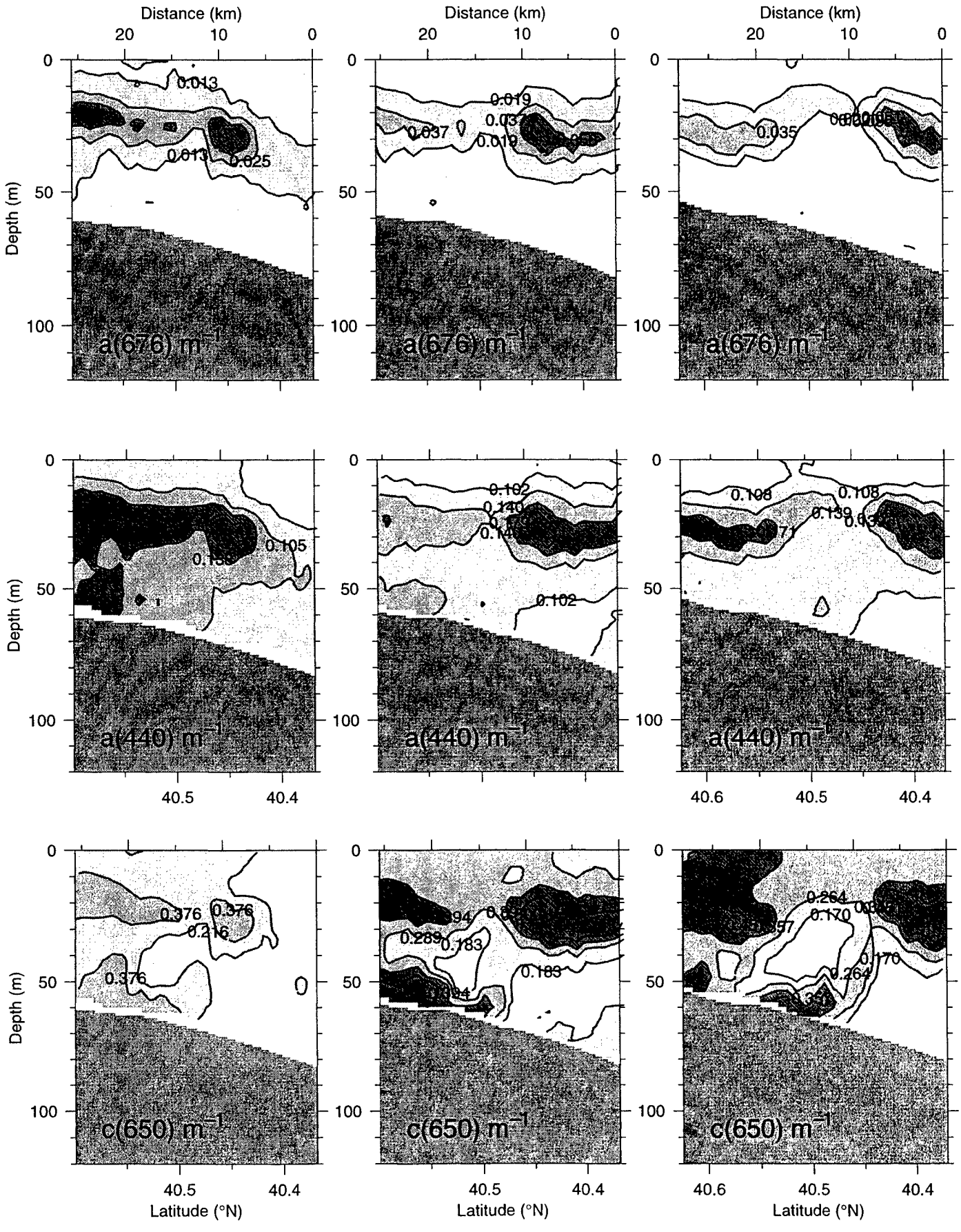
# E9608 Smallbox 3



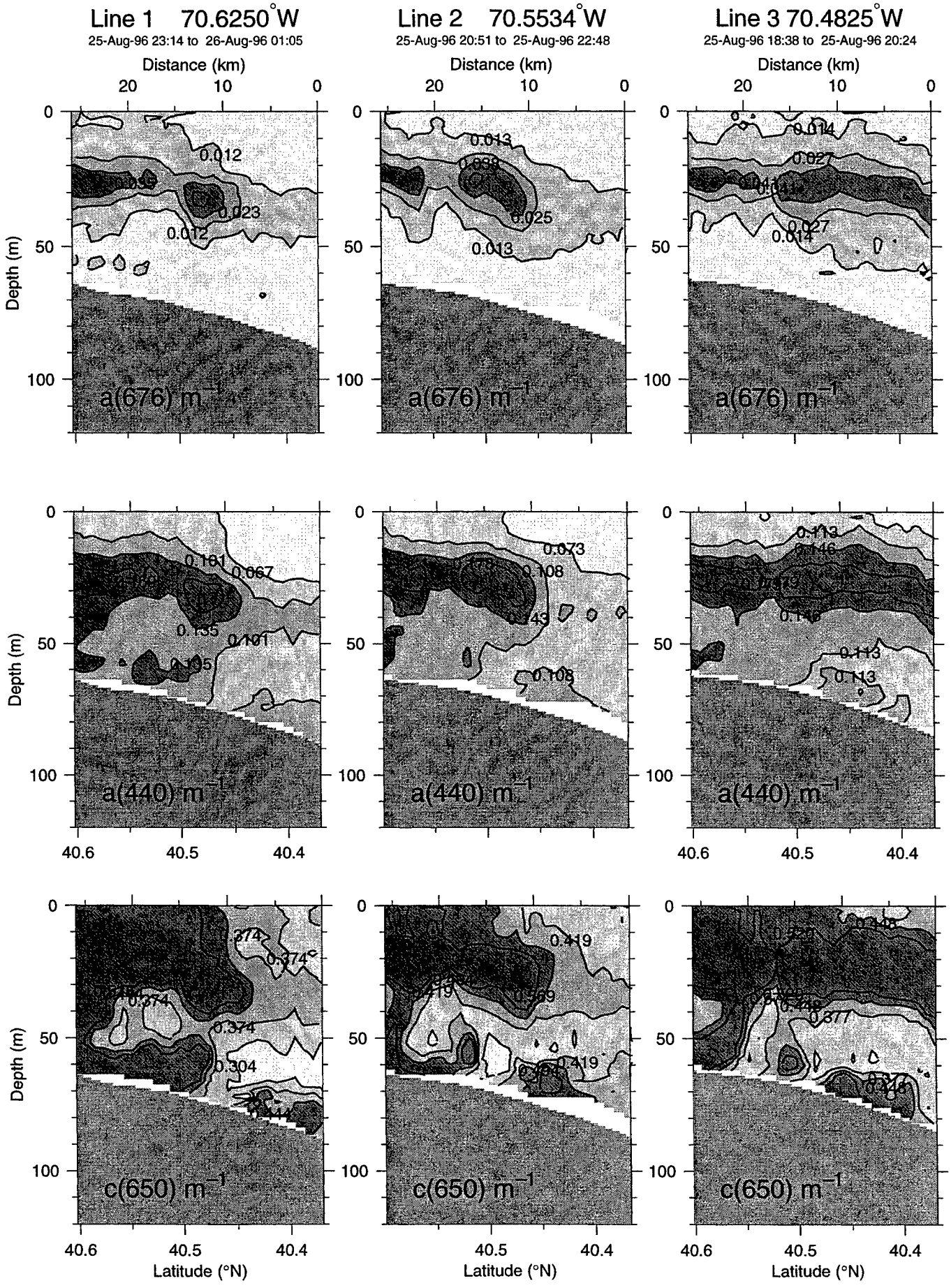
# E9608 Smallbox 4



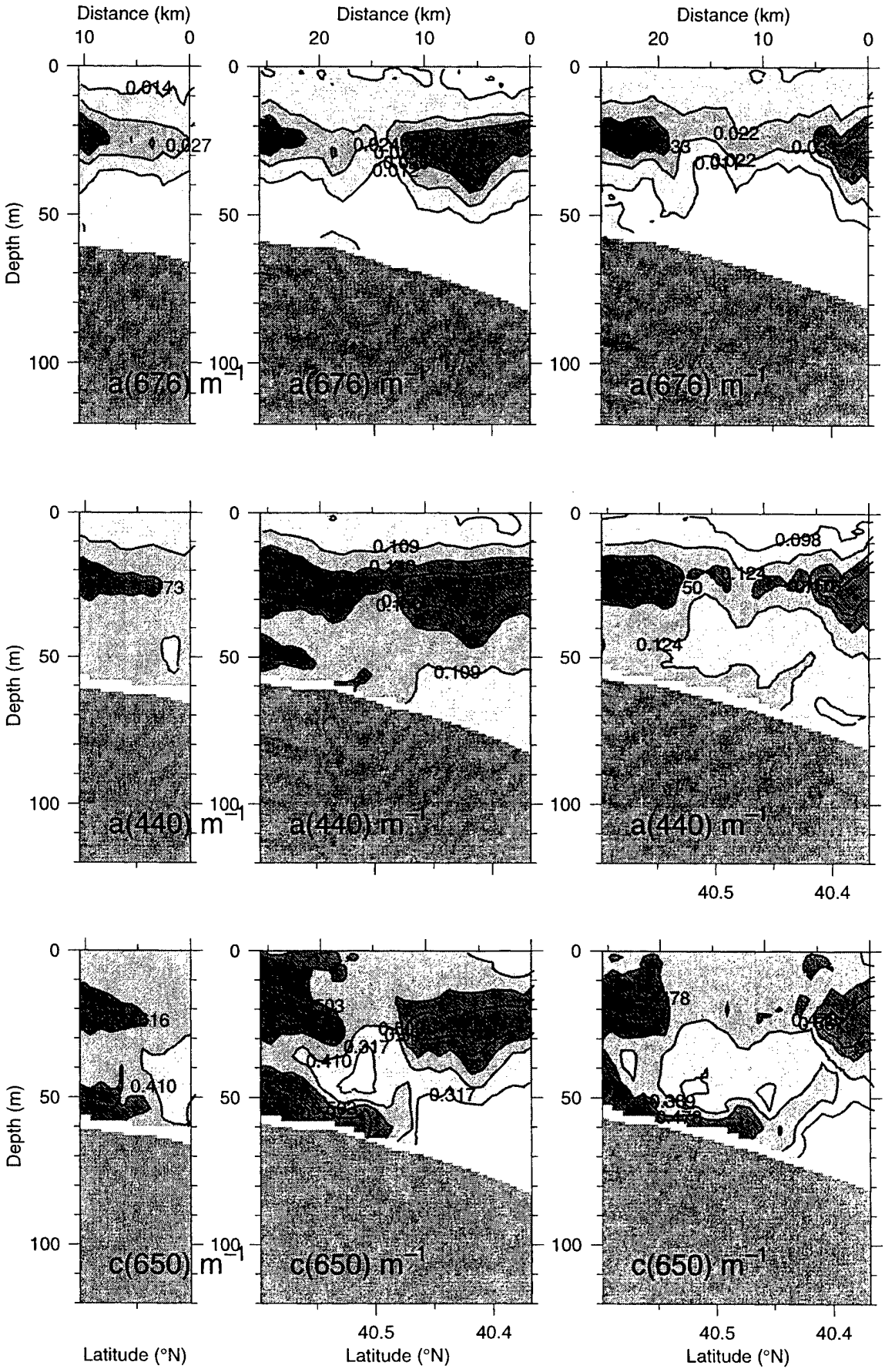
# E9608 Smallbox 4



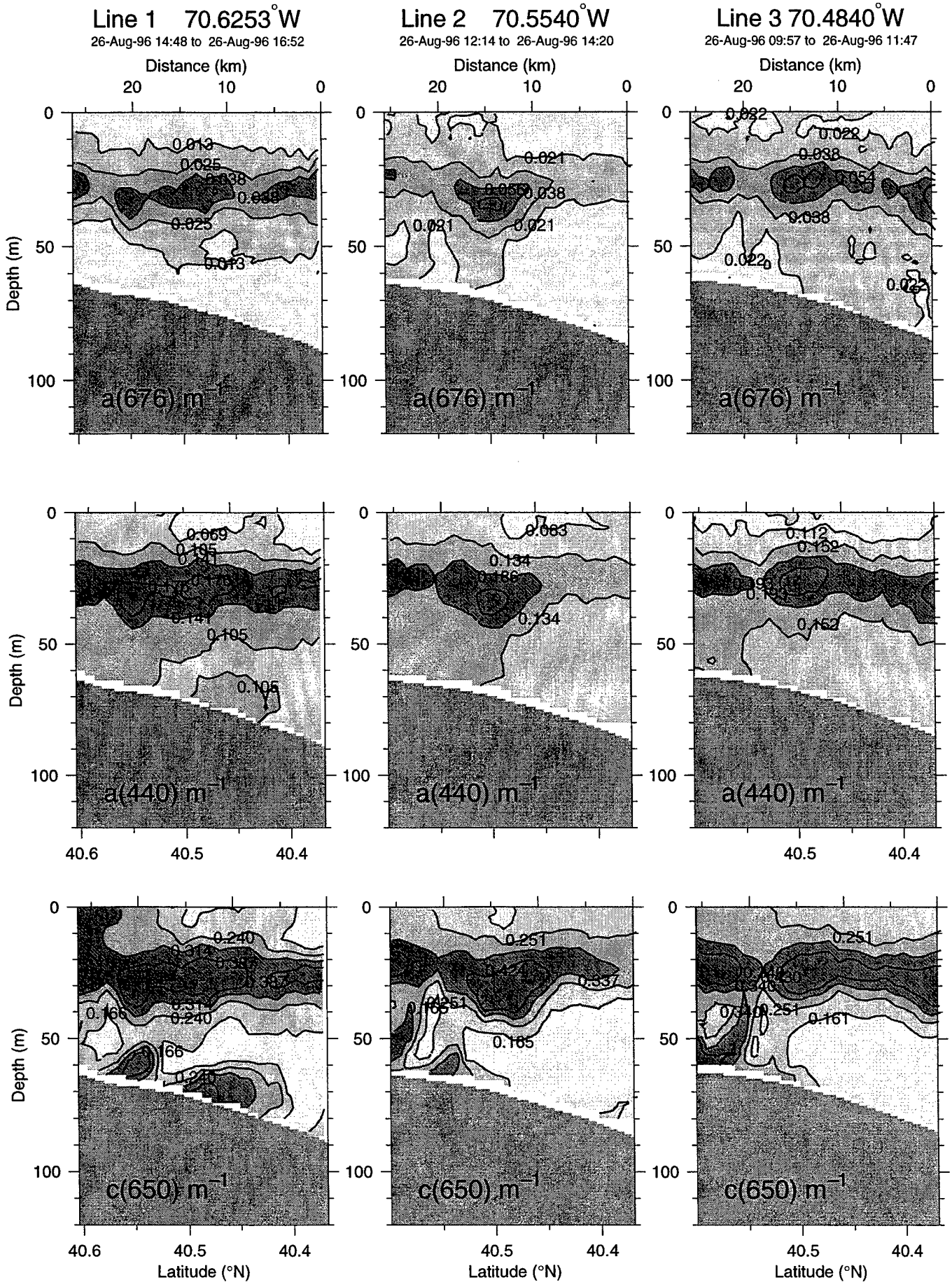
# E9608 Smallbox 5



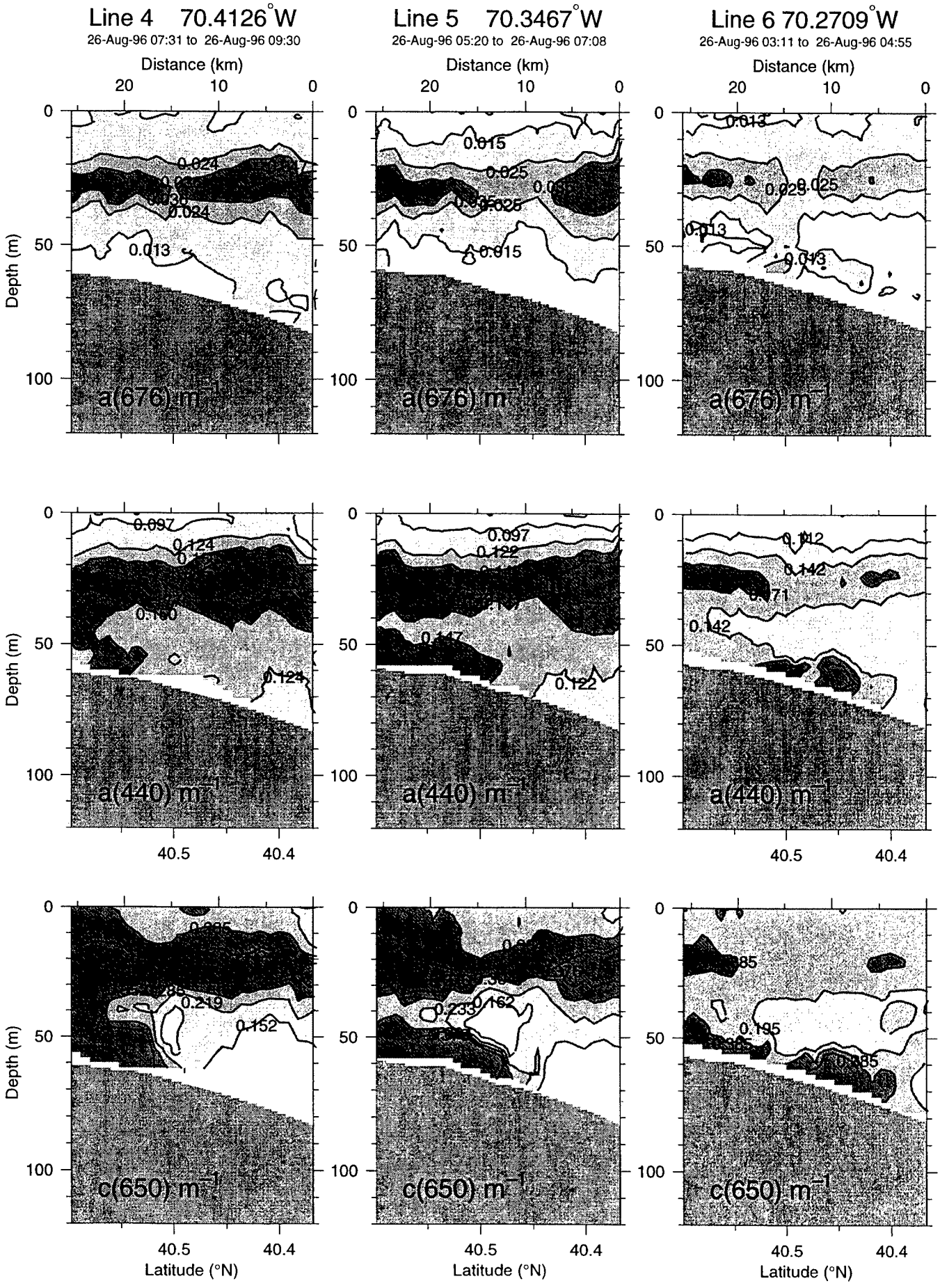
# E9608 Smallbox 5



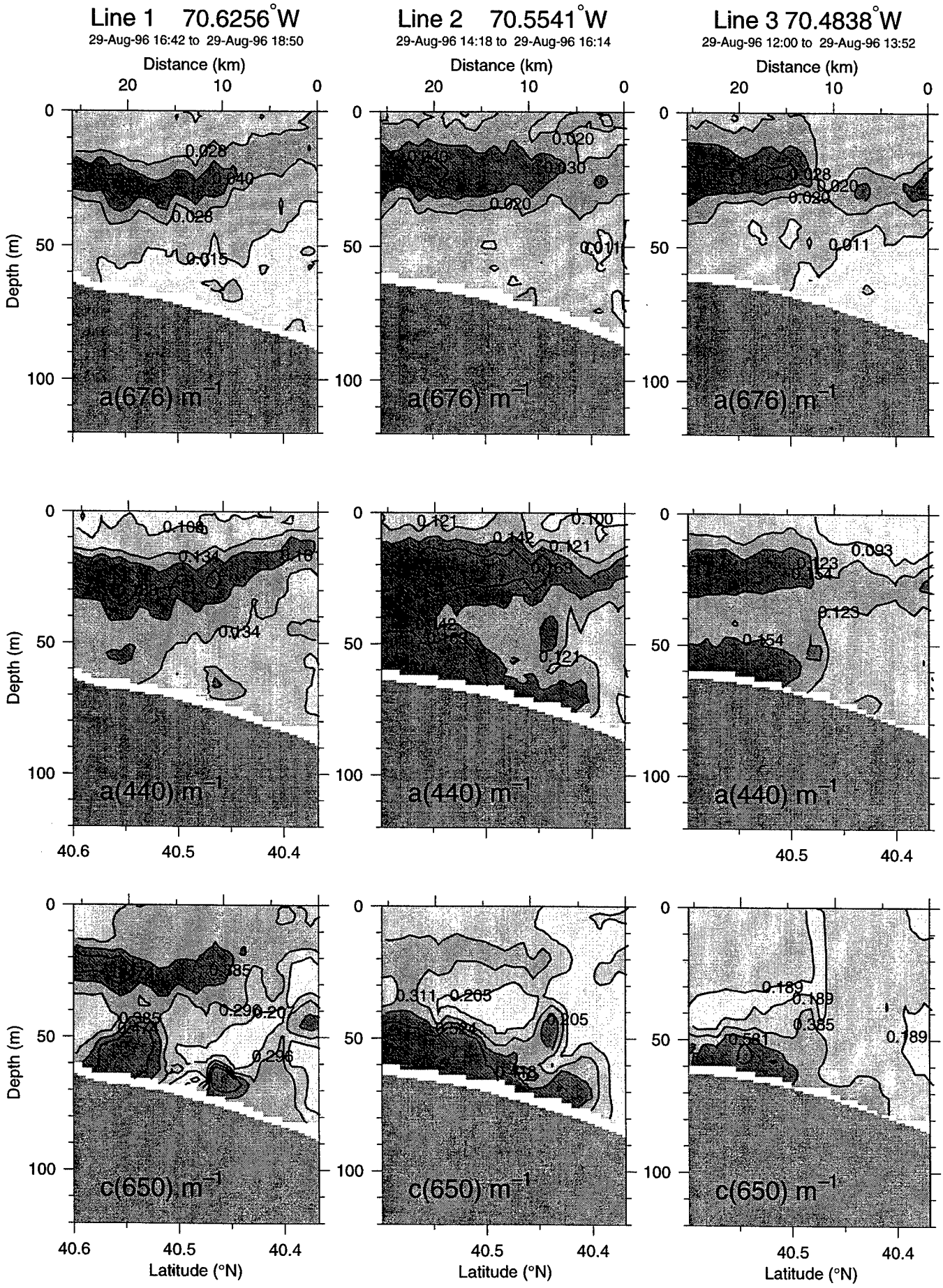
# E9608 Smallbox 6



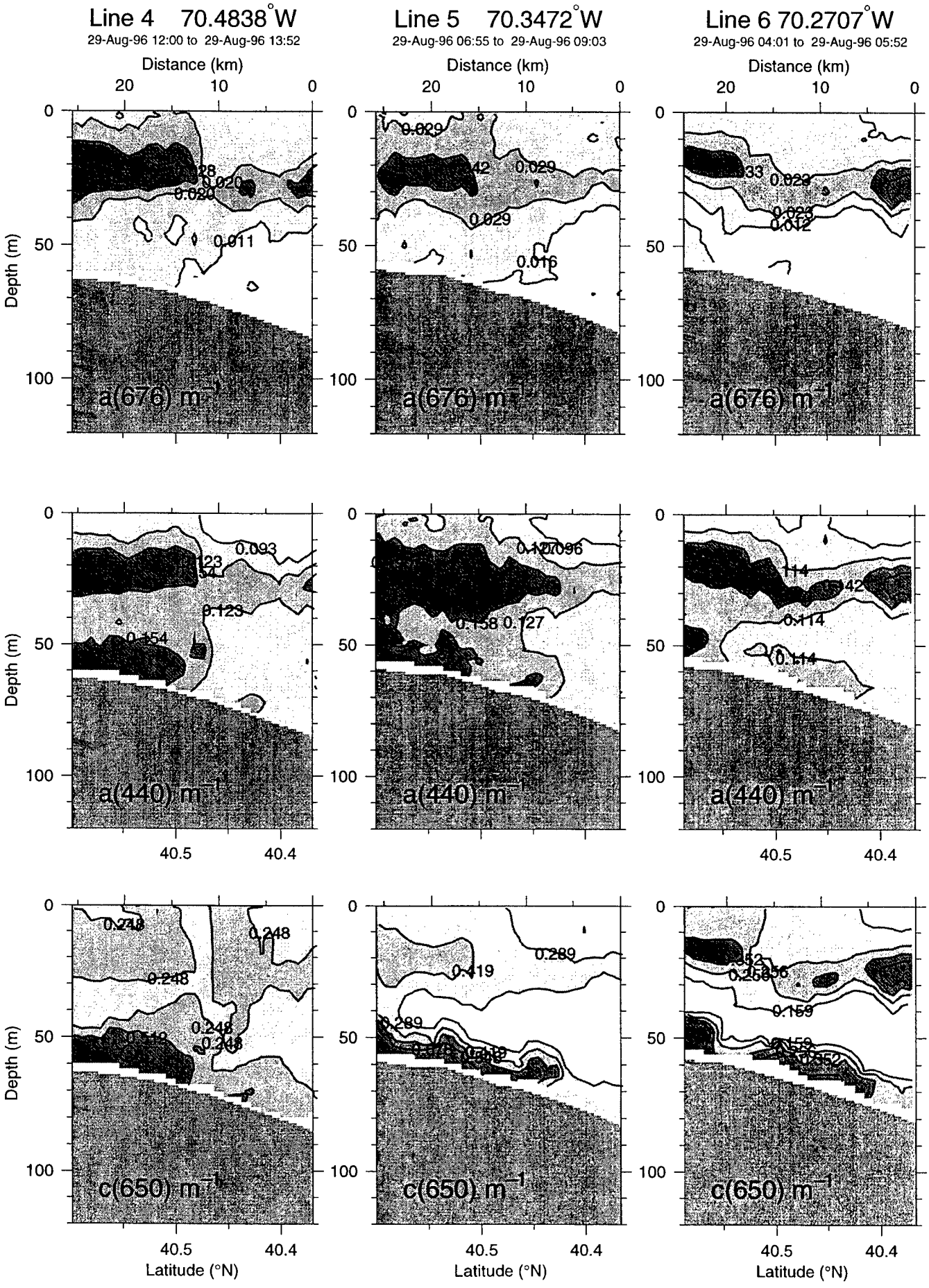
# E9608 Smallbox 5



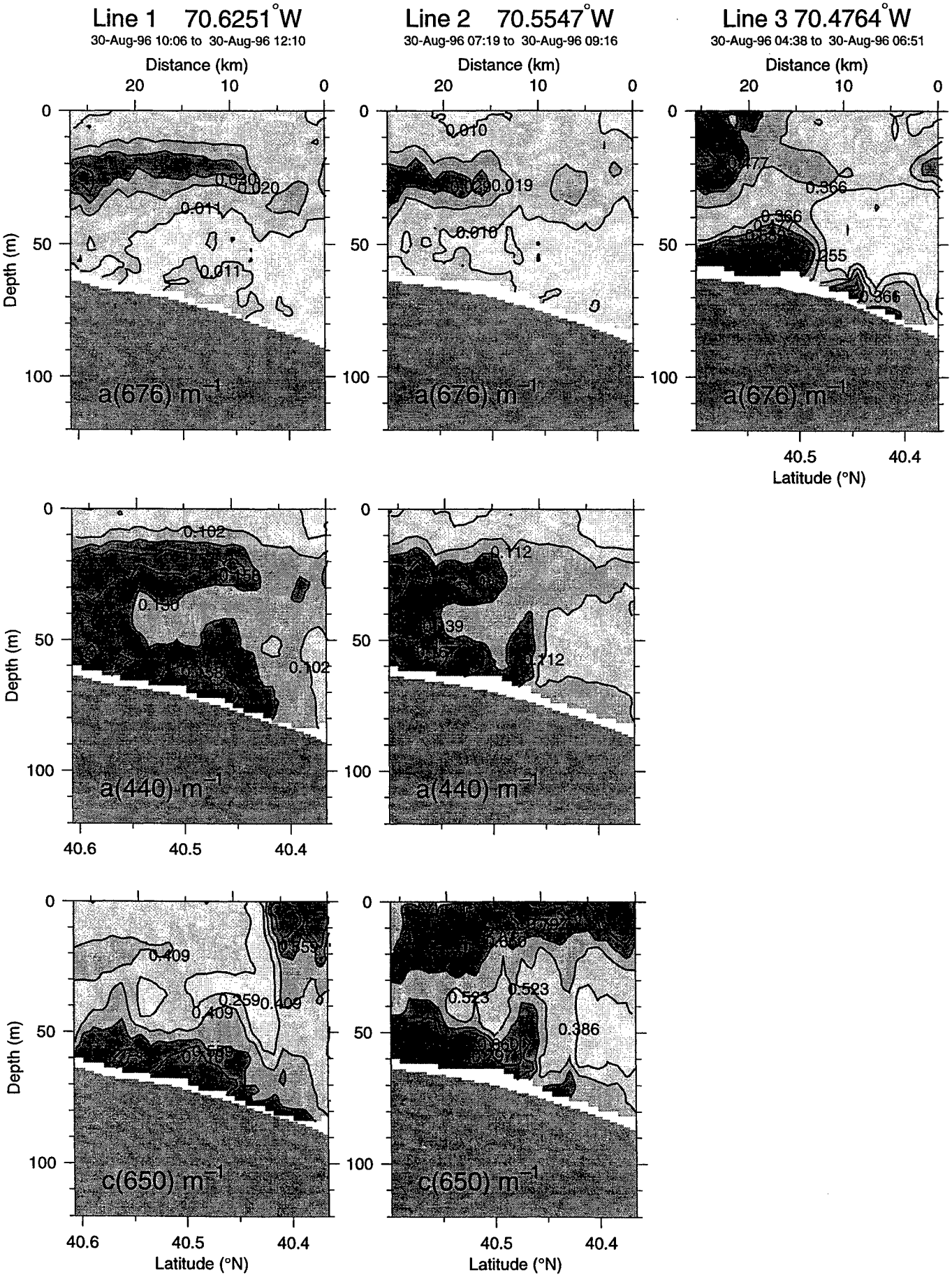
# E9608 Smallbox 7



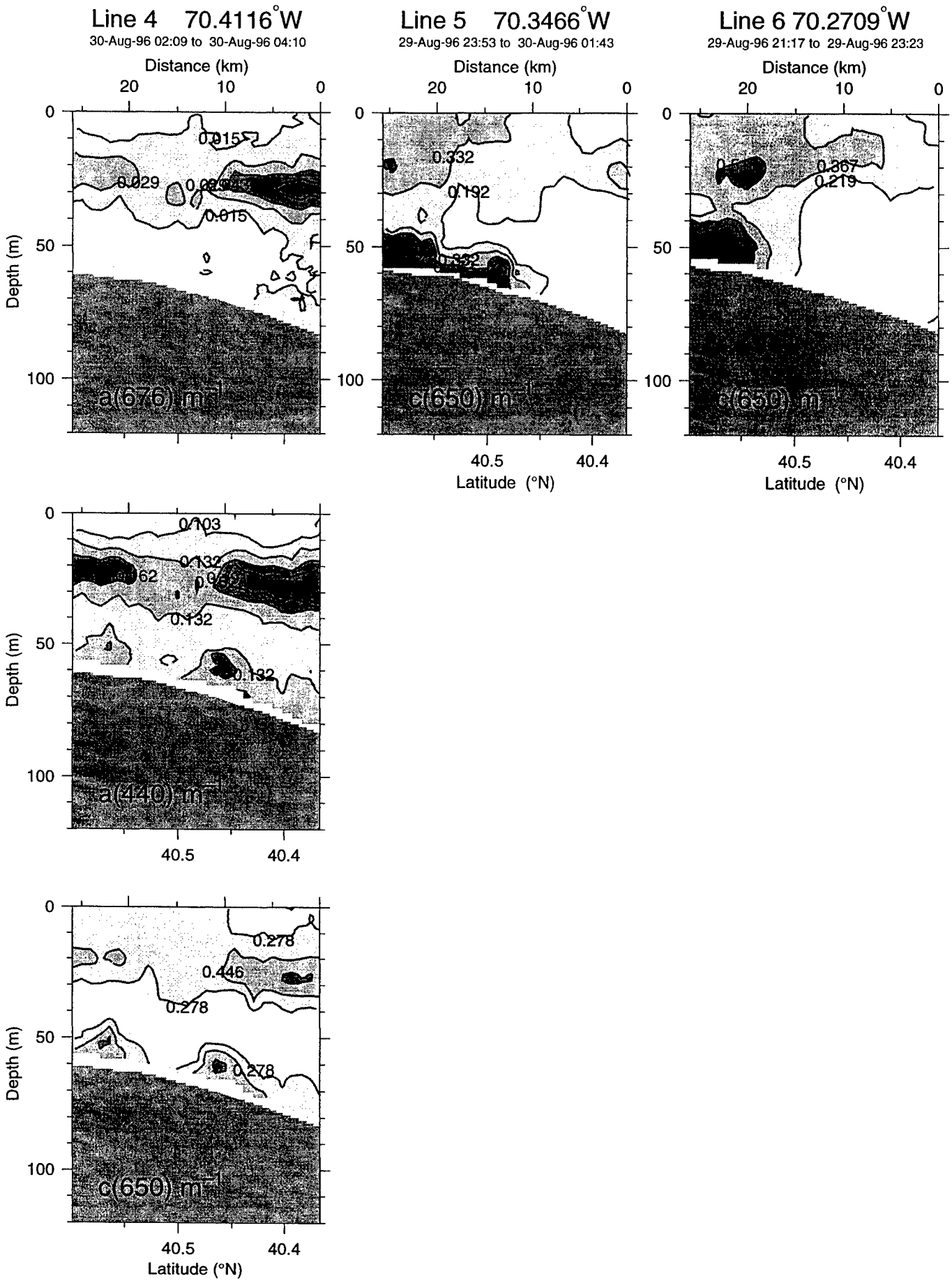
# E9608 Smallbox 7



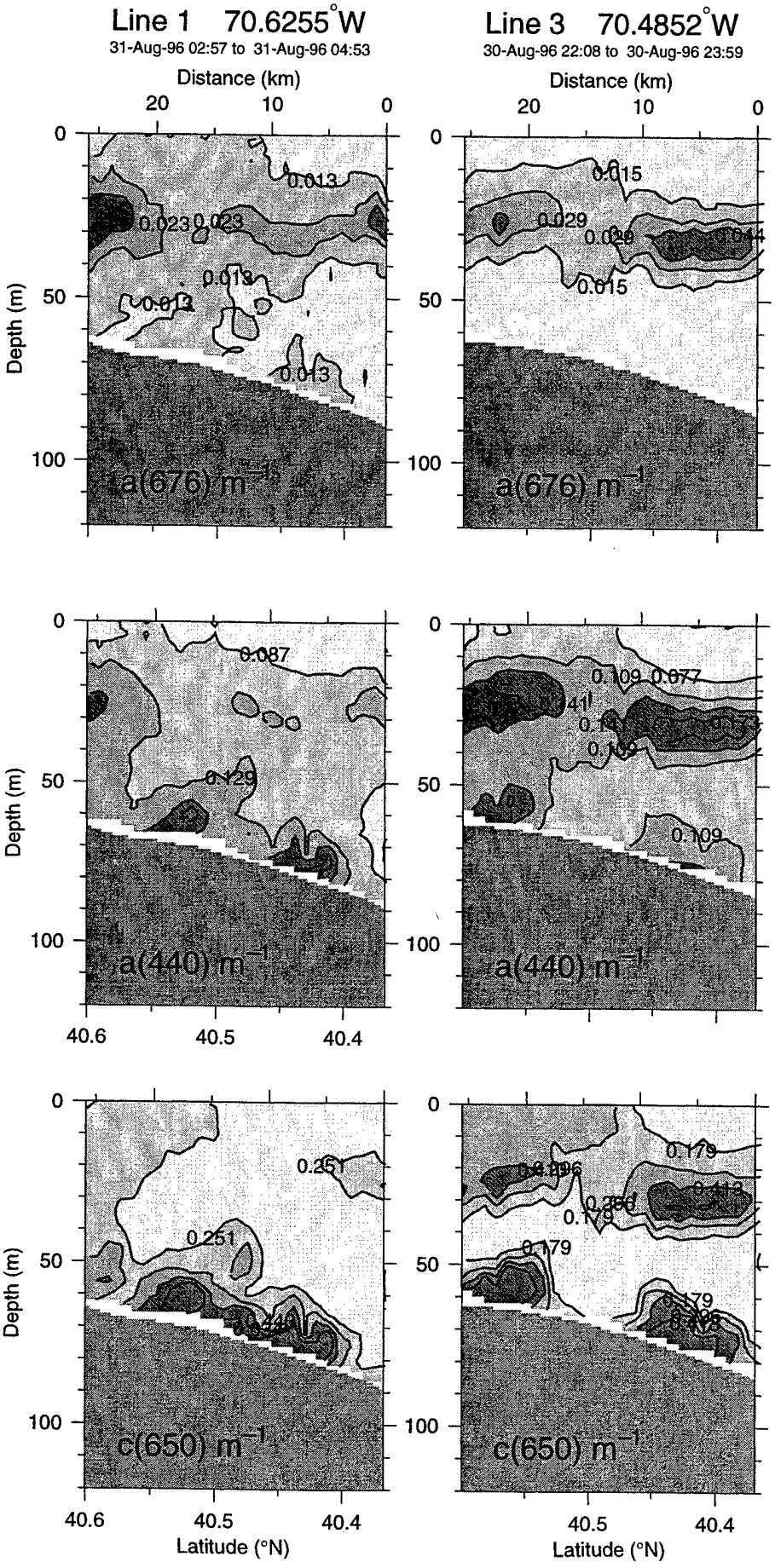
# E9608 Smallbox 8



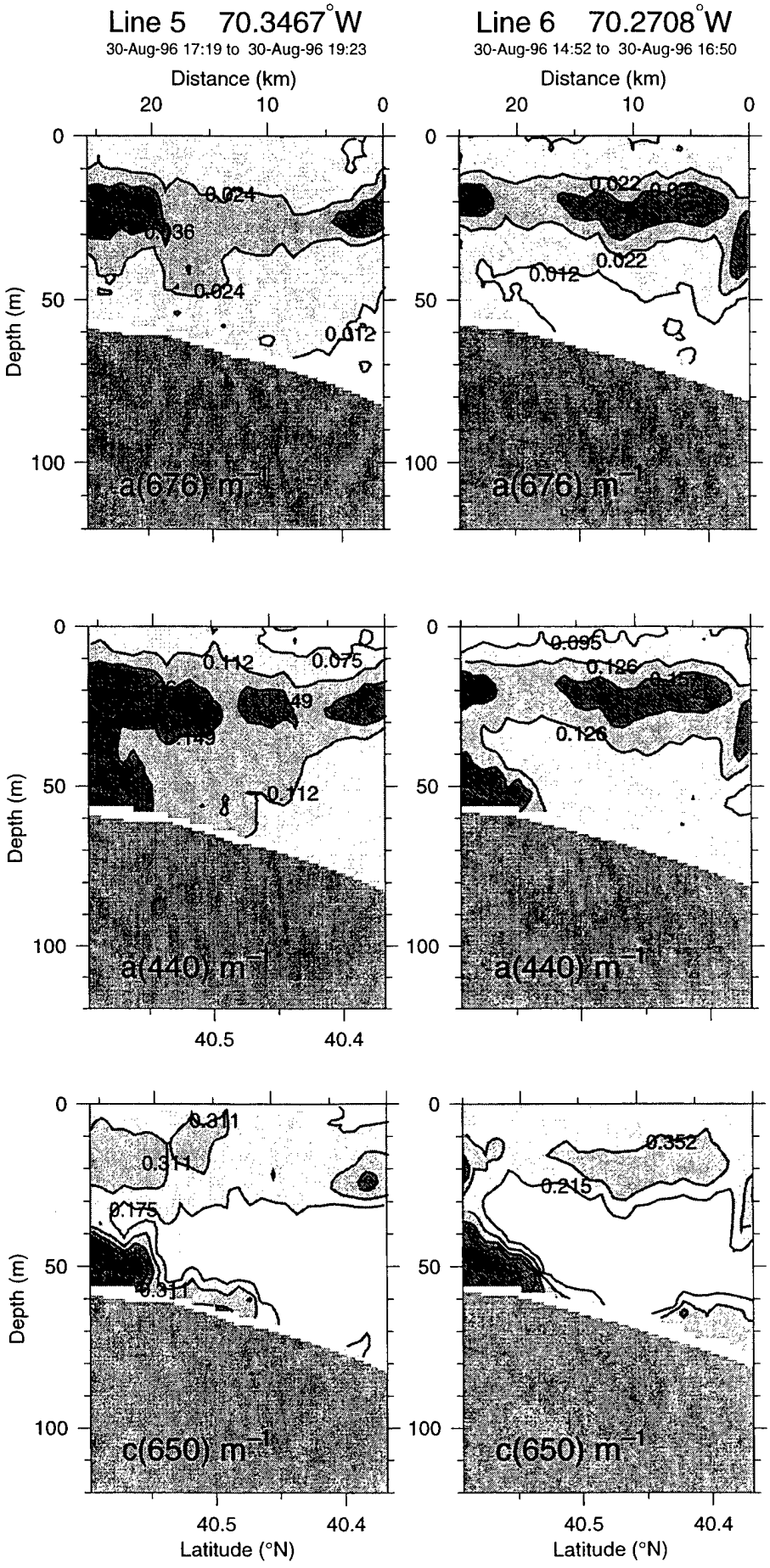
# E9608 Smallbox 8



# E9608 Smallbox 9

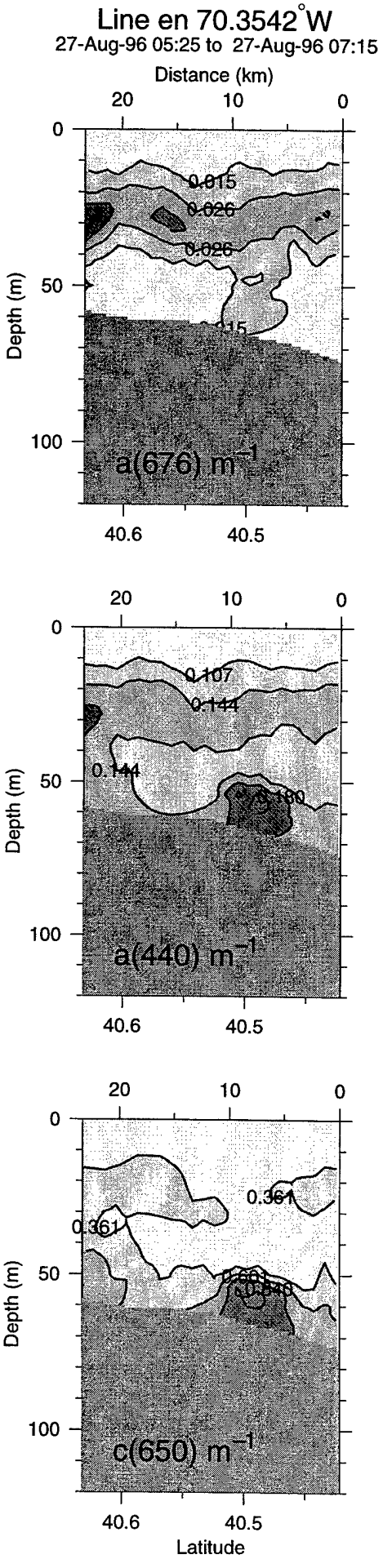


# E9608 Smallbox 9

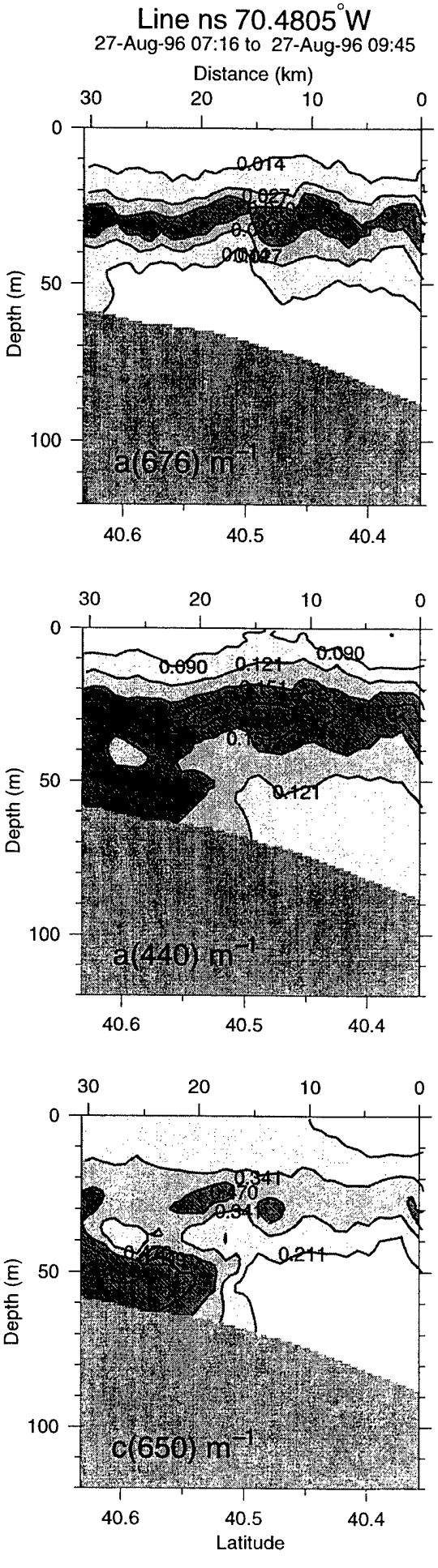


# E9608 Butterfly Sections

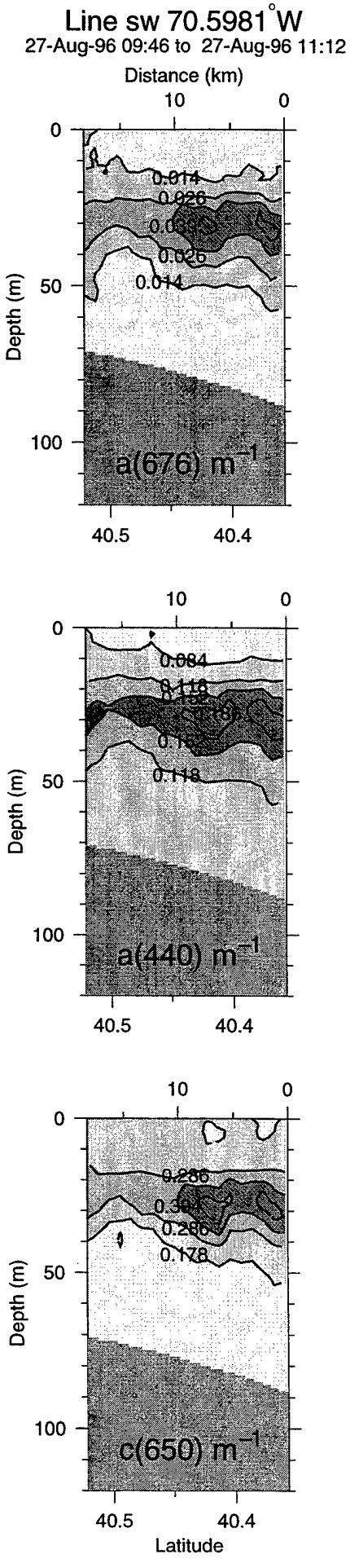
# Butterfly 1


Line en 70.3542°W
27-Aug-96 05:25 to 27-Aug-96 07:15
Distance (km)
20
10
0
Depth (m)
0
50
100
0.015
0.026
0.026
0.015
a(676) m⁻¹
40.6
40.5
0.107
0.144
0.144
0.160
a(440) m⁻¹
0.361
0.361
0.660
0.546
c(650) m⁻¹
Latitude

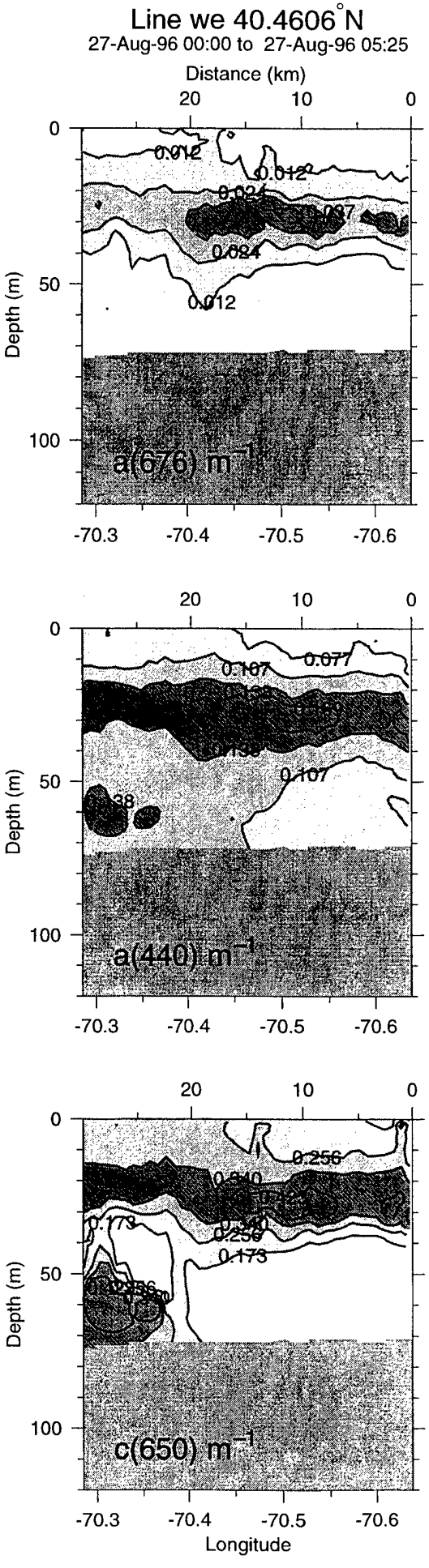
# Butterfly 1


Line ns 70.4805°W
27-Aug-96 07:16 to 27-Aug-96 09:45
Distance (km)
30
20
10
0
Depth (m)
0
50
100
0.014
0.027
0.047
a(676) m⁻¹
40.6
40.5
40.4
0.090
0.121
a(440) m⁻¹
0.341
0.270
0.211
c(650) m⁻¹
Latitude

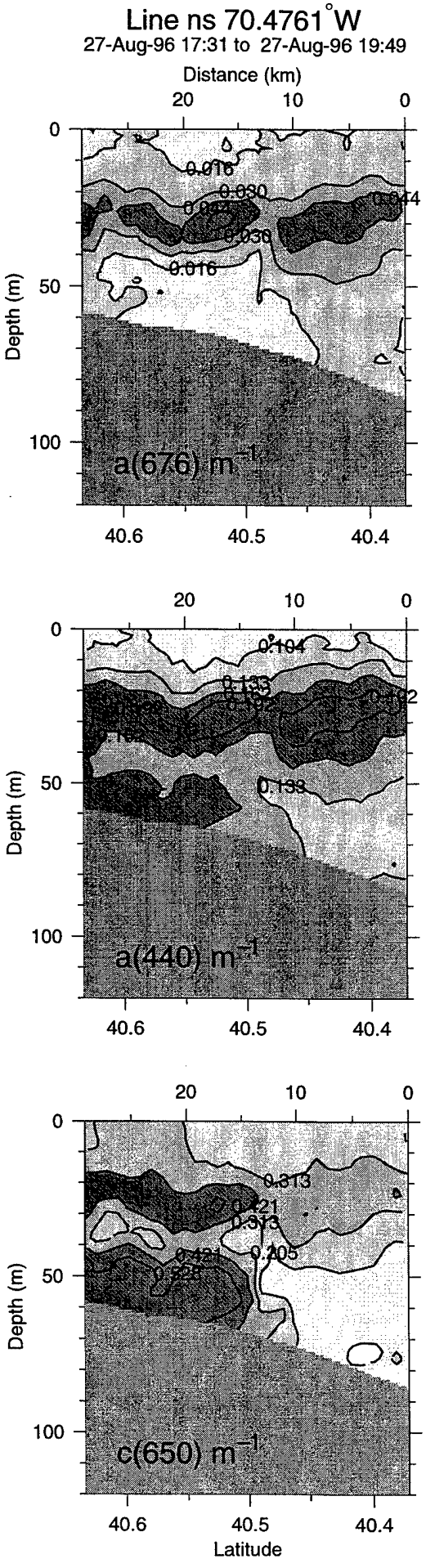
# Butterfly 1


Line sw 70.5981°W
27-Aug-96 09:46 to 27-Aug-96 11:12
Distance (km)
10
0
Depth (m)
0
50
100
0.014
0.026
0.026
0.014
a(676) m⁻¹
40.5
40.4
0.084
0.118
0.118
a(440) m⁻¹
0.286
0.178
c(650) m⁻¹
Latitude

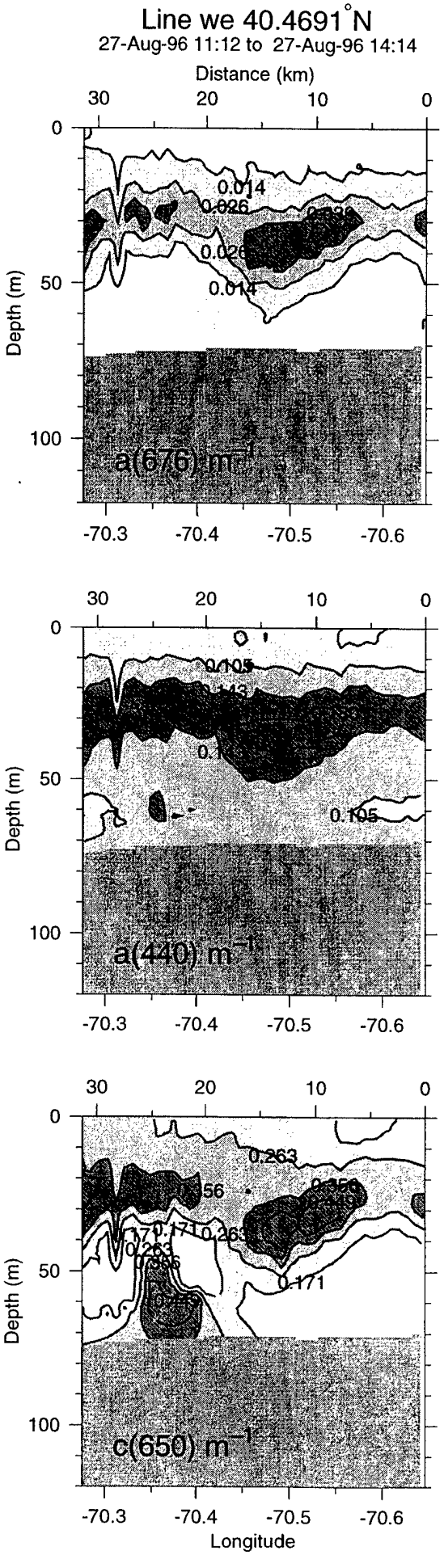
# Butterfly 1


Line we 40.4606°N
27-Aug-96 00:00 to 27-Aug-96 05:25
Distance (km)
20
10
0
Depth (m)
0
50
100
0.012
0.012
0.024
0.024
0.012
a(676) m⁻¹
-70.3
-70.4
-70.5
-70.6
0.107
0.077
0.107
38
a(440) m⁻¹
0.256
0.173
0.256
0.173
c(650) m⁻¹
Longitude

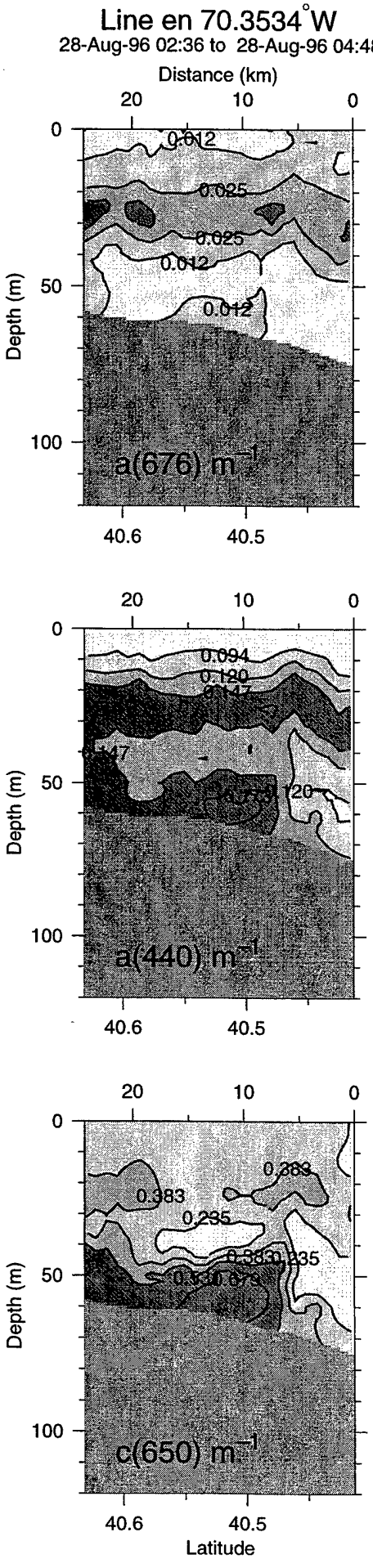
# Butterfly 2


Line ns 70.4761°W
27-Aug-96 17:31 to 27-Aug-96 19:49
Distance (km)
20
10
0
Depth (m)
0
50
100
0.016
0.030
0.044
0.030
0.016
a(676) m⁻¹
40.6
40.5
40.4
0.104
0.133
0.192
0.133
a(440) m⁻¹
0.313
0.421
0.313
0.205
0.421
c(650) m⁻¹
Latitude

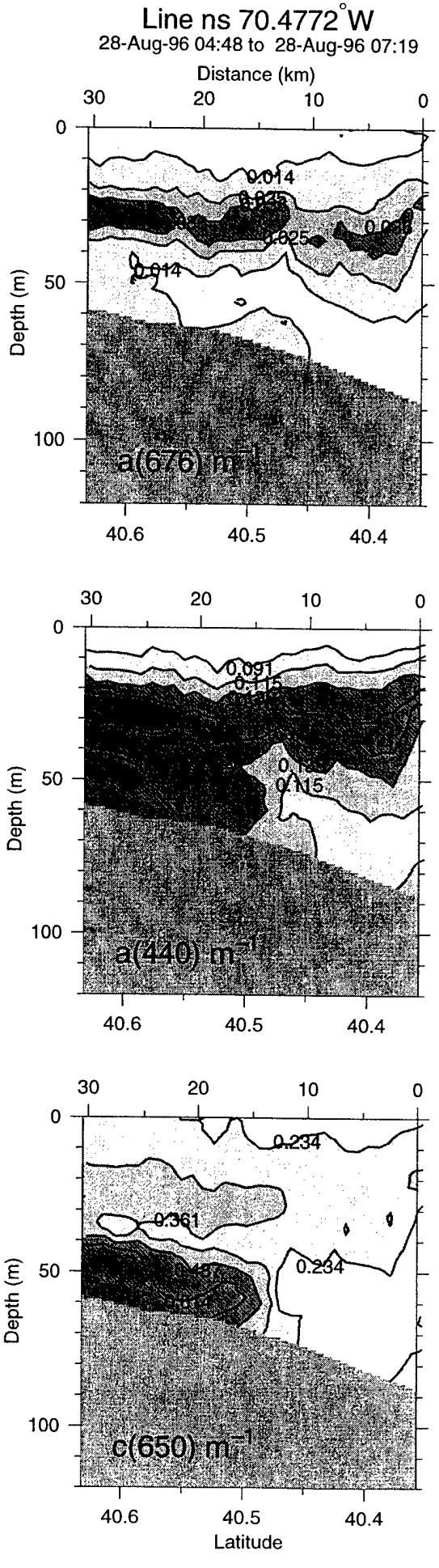
# Butterfly 2


Line we 40.4691°N
27-Aug-96 11:12 to 27-Aug-96 14:14
Distance (km)
30
20
10
0
Depth (m)
0
50
100
0.014
0.026
0.026
0.014
a(676) m⁻¹
-70.3
-70.4
-70.5
-70.6
0.105
0.105
a(440) m⁻¹
0.263
0.171
0.171
0.263
0.171
c(650) m⁻¹
Longitude

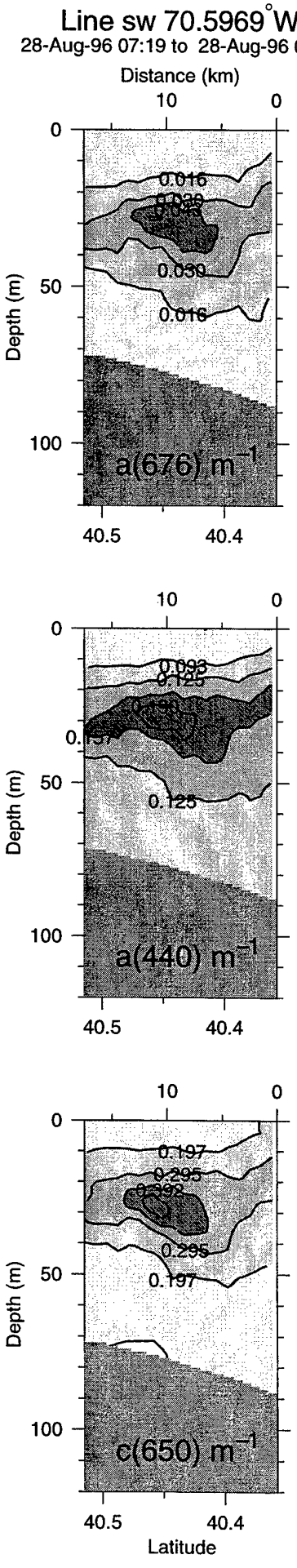
# Butterfly 3


Line en 70.3534°W
28-Aug-96 02:36 to 28-Aug-96 04:48
Distance (km)
20
10
0
Depth (m)
0
50
100
0.012
0.025
0.025
0.012
0.012
a(676) m⁻¹
40.6
40.5
0.094
0.120
0.120
a(440) m⁻¹
0.383
0.383
0.235
0.235
c(650) m⁻¹
Latitude

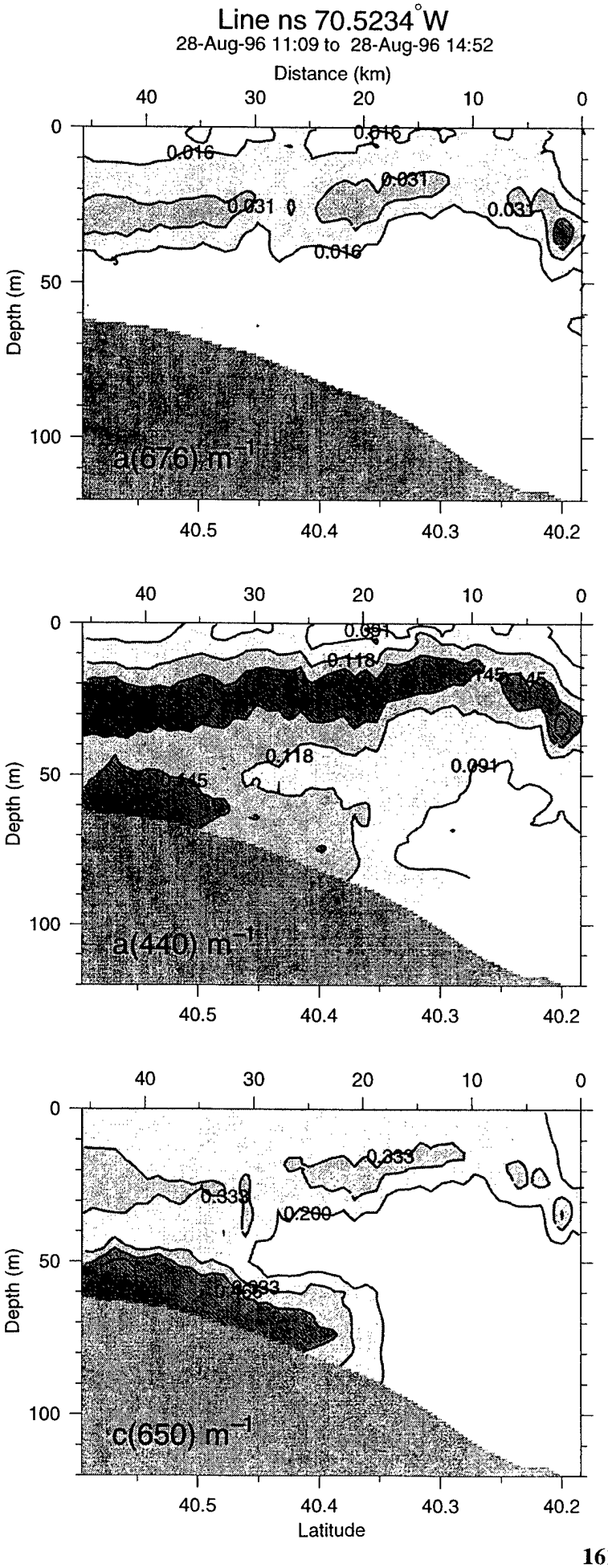
# Butterfly 3


Line ns 70.4772°W
28-Aug-96 04:48 to 28-Aug-96 07:19
Distance (km)
30
20
10
0
Depth (m)
0
50
100
0.014
0.025
0.014
a(676) m⁻¹
40.6
40.5
40.4
0.091
0.115
0.115
a(440) m⁻¹
0.234
0.361
0.234
c(650) m⁻¹
Latitude

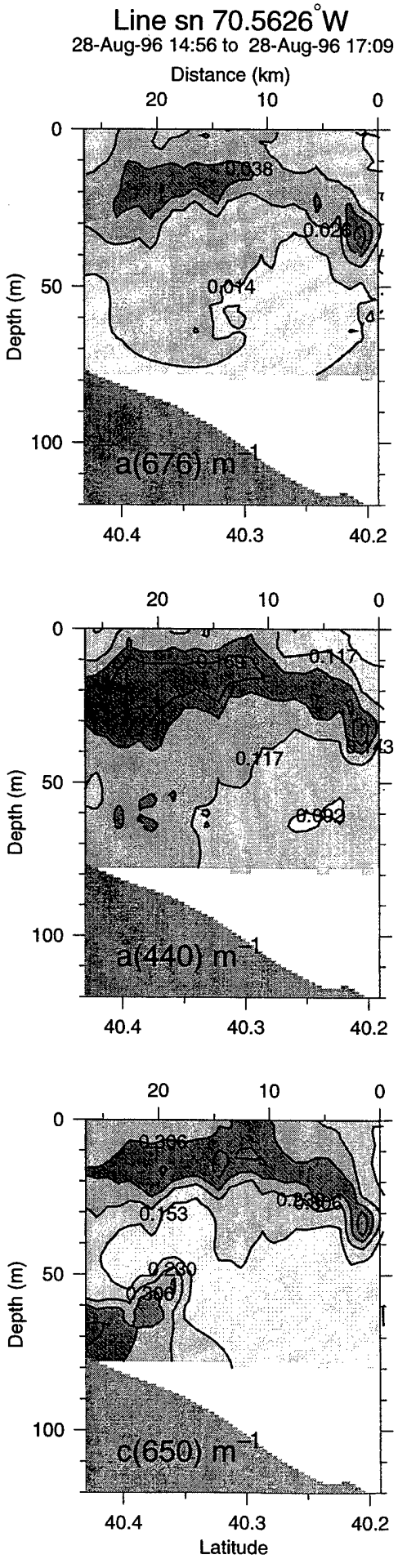
# Butterfly 3


Line sw 70.5969°W
28-Aug-96 07:19 to 28-Aug-96 08:51
Distance (km)
10
0
Depth (m)
0
50
100
0.016
0.030
0.030
0.016
a(676) m⁻¹
40.5
40.4
0.093
0.125
0.125
a(440) m⁻¹
0.197
0.295
0.295
0.197
c(650) m⁻¹
Latitude

# Butterfly 4


Line ns 70.5234°W
28-Aug-96 11:09 to 28-Aug-96 14:52
Distance (km)
40
30
20
10
0
Depth (m)
0
50
100
0.016
0.031
a(676) m⁻¹
40.5
40.4
40.3
40.2
0.091
0.118
a(440) m⁻¹
0.333
0.200
c(650) m⁻¹
Latitude

# Butterfly 4


Line sn 70.5626°W
28-Aug-96 14:56 to 28-Aug-96 17:09
Distance (km)
20
10
0
Depth (m)
0
50
100
0.038
0.014
a(676) m⁻¹
40.4
40.3
40.2
0.109
0.117
0.717
0.992
a(440) m⁻¹
0.206
0.153
0.230
0.206
c(650) m⁻¹
Latitude

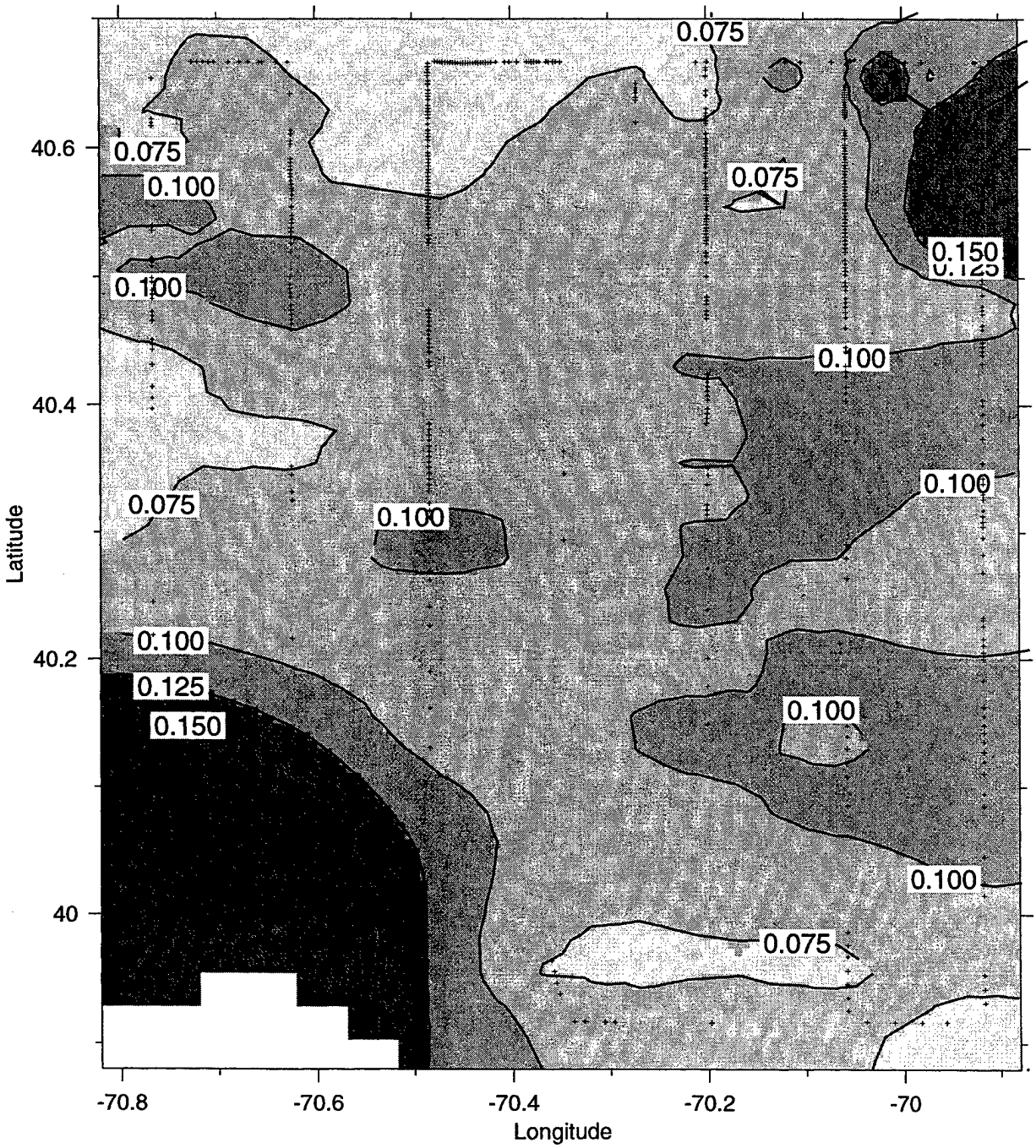
# E9704 Bigbox Maps

# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at 5 m**

a(676) $m^{-1}$

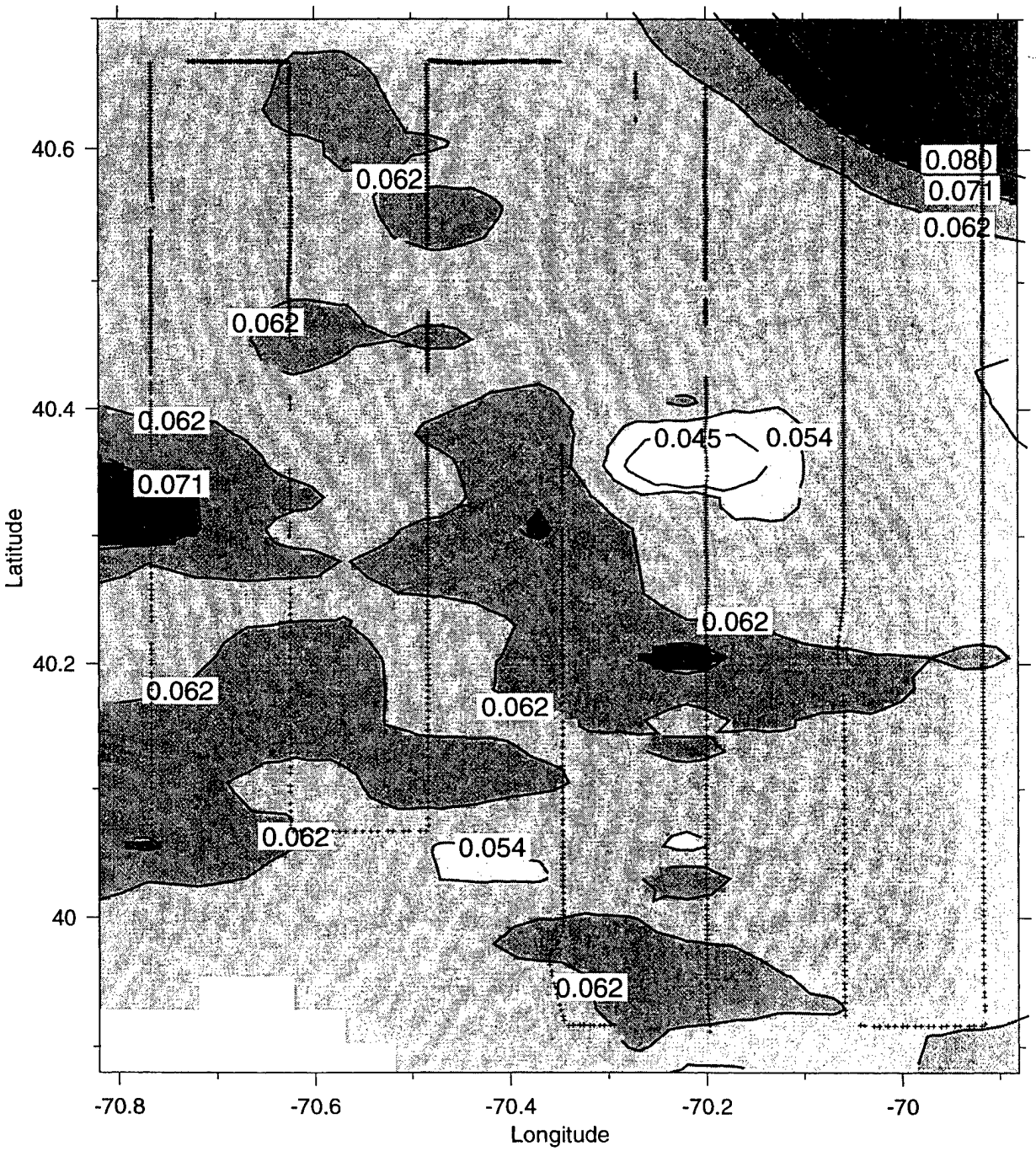


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at 45 m**

a(676) $m^{-1}$

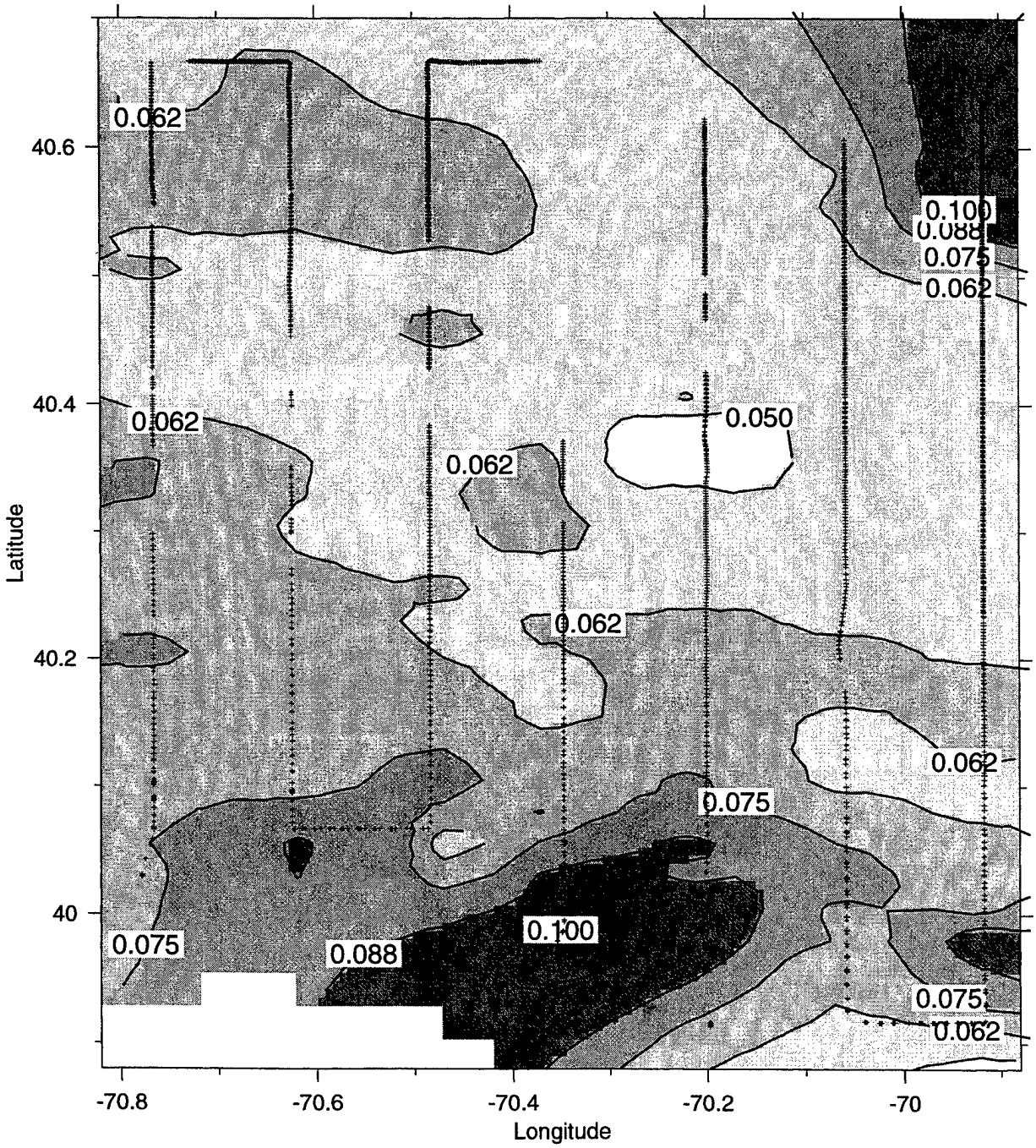


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at $\sigma_t$ = 25.4 ± 0.025 kg/m$^3$**

a(676) m$^{-1}$

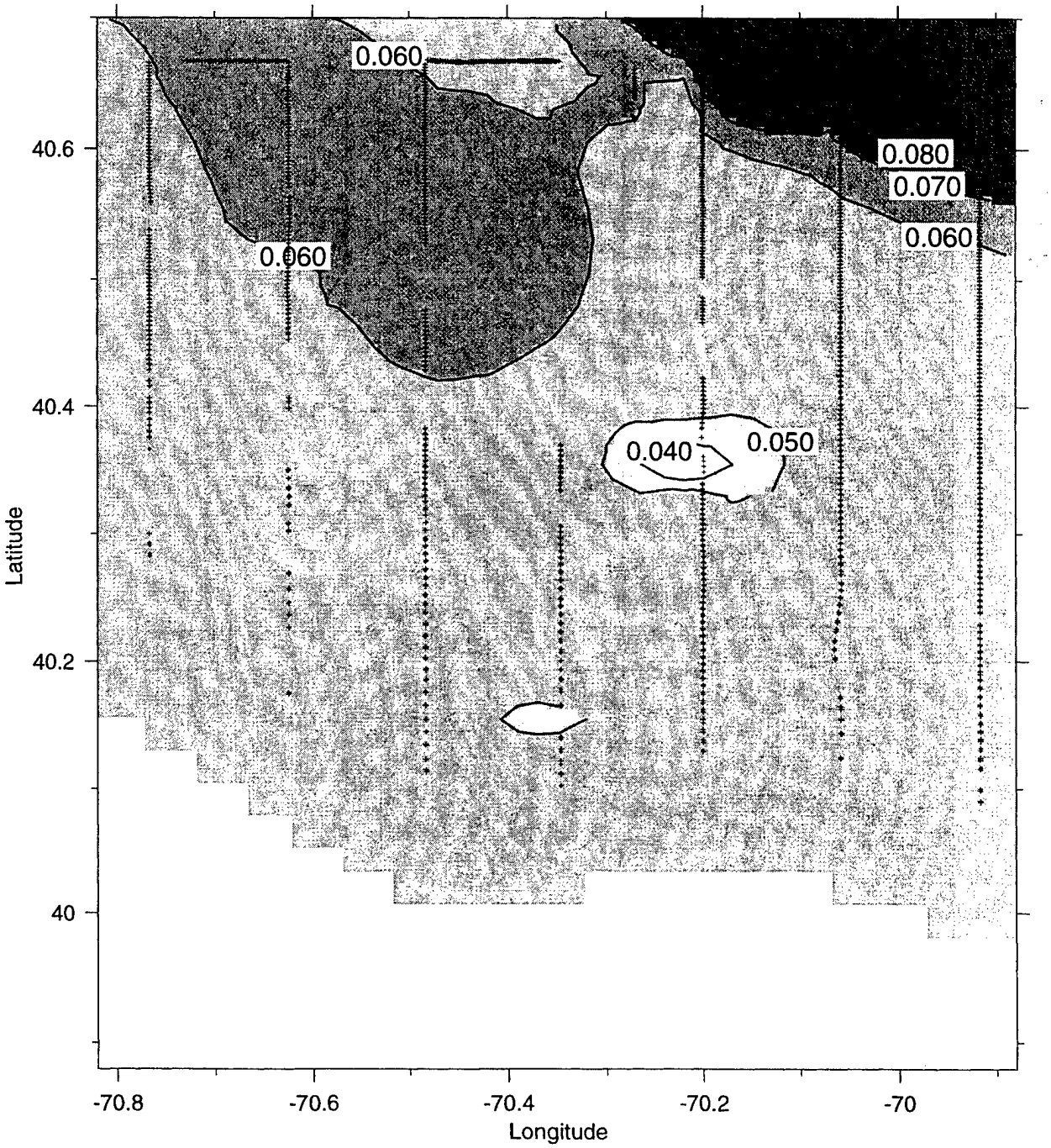


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at 10 m above bottom**

a(676) $m^{-1}$

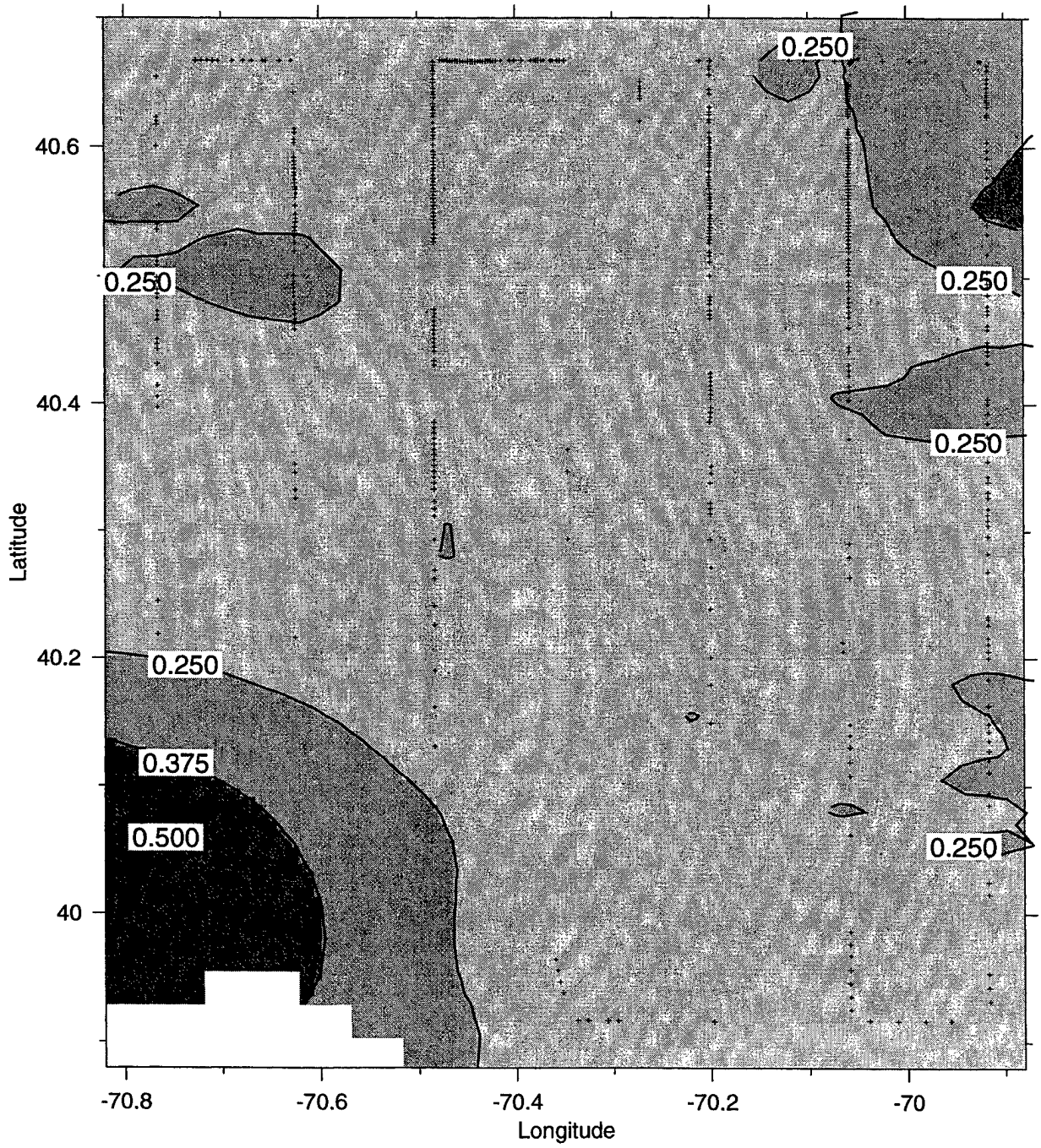


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at 5 m**

a(440) $m^{-1}$

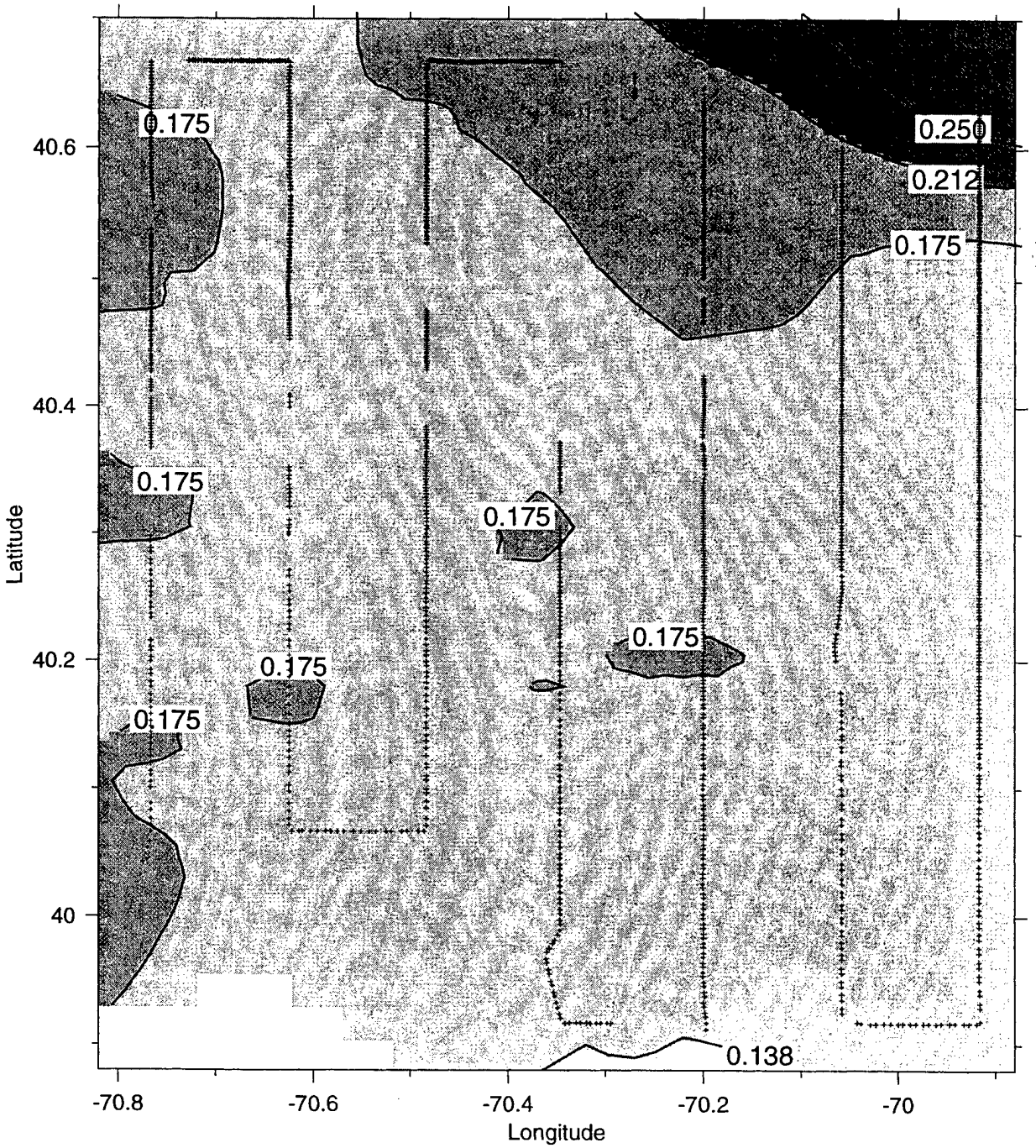


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at 45 m**

a(440) $m^{-1}$

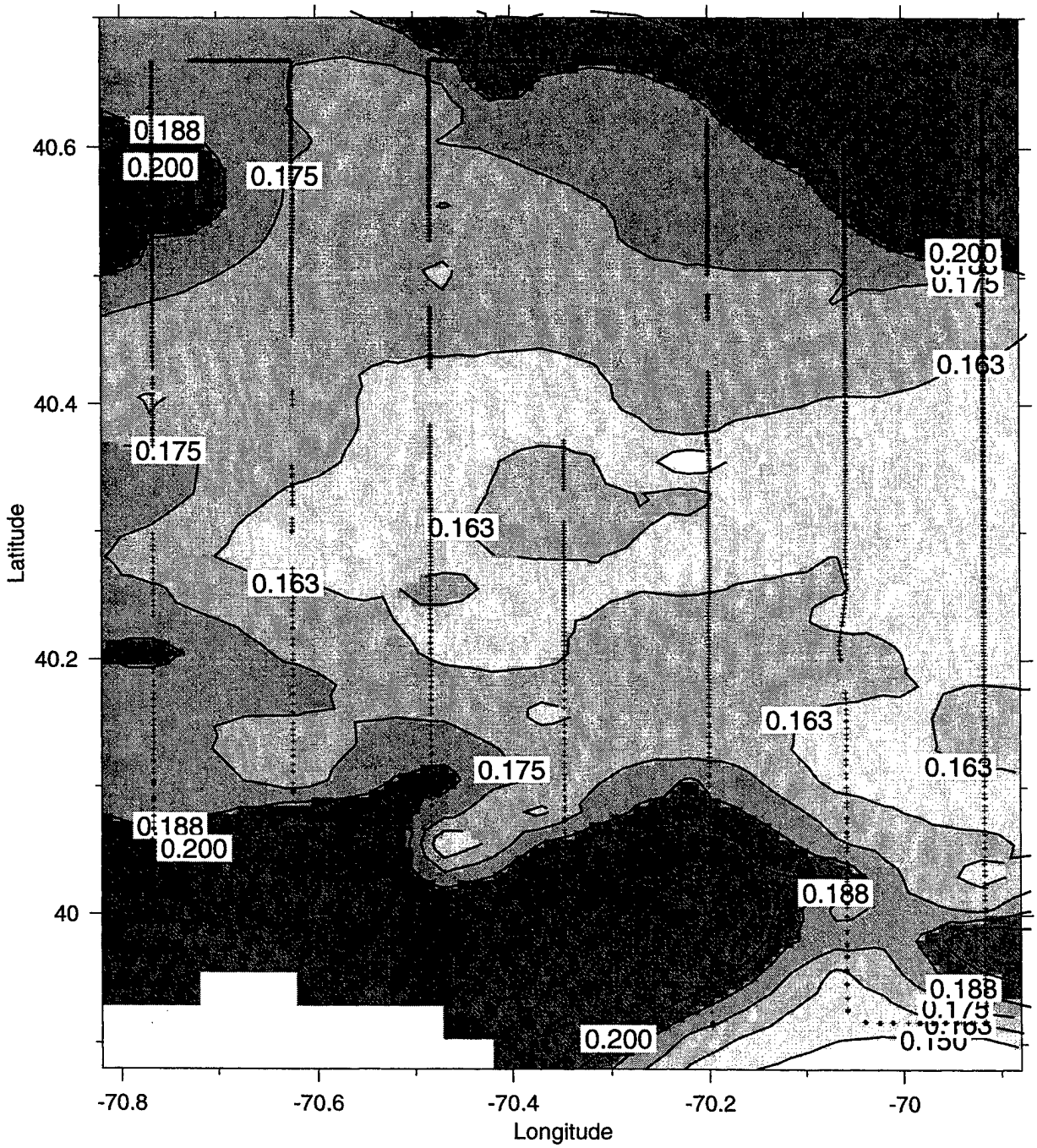


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at $\sigma_t$ = 25.4 ± 0.025 kg/m$^3$**

a(440) m$^{-1}$

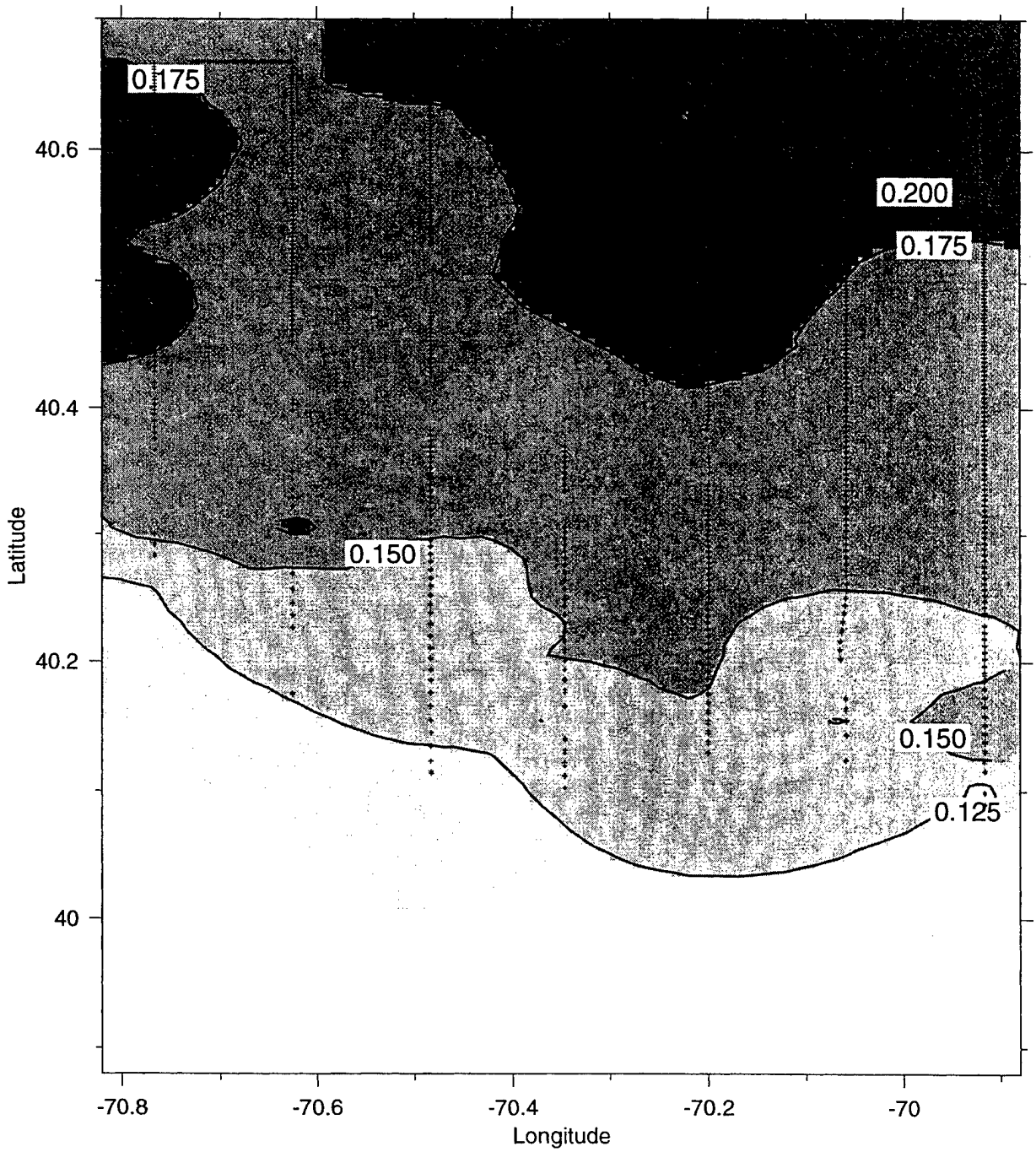


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at 10 m above bottom**

a(440) $m^{-1}$

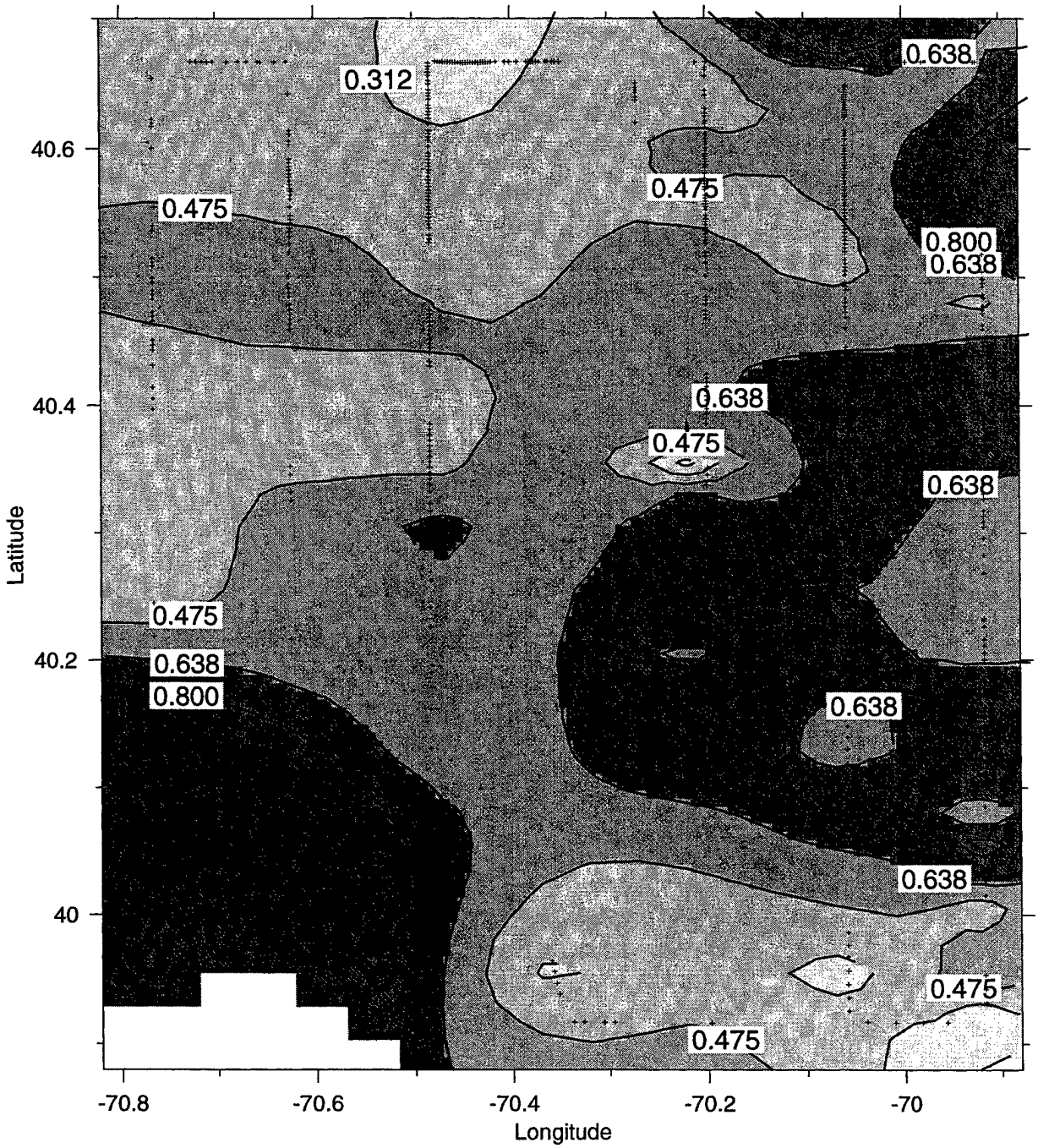


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at 5 m**

c(650) $m^{-1}$

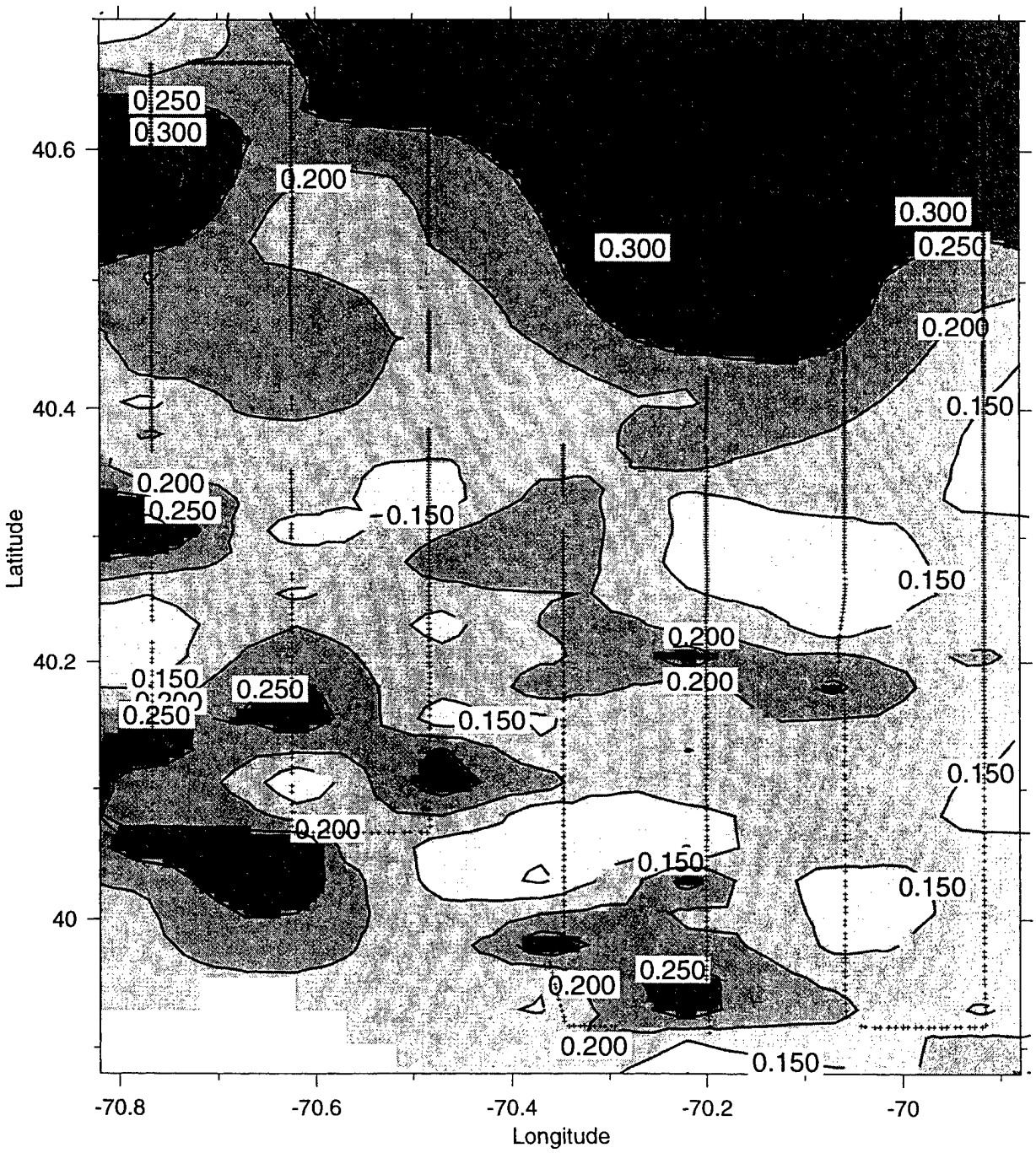


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at 45 m**

c(650) $m^{-1}$

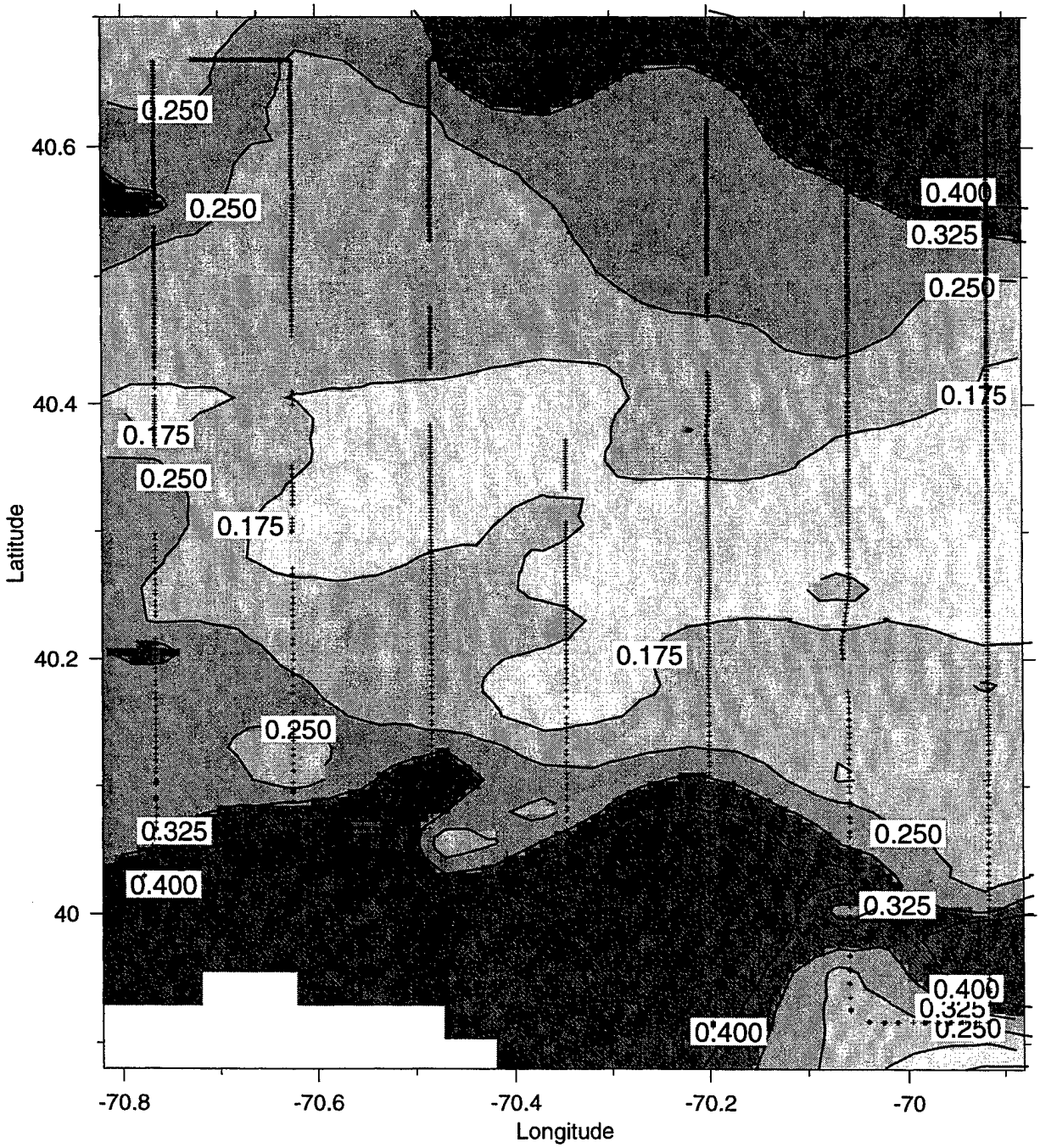


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at $\sigma_t$ = 25.4 ± 0.025 kg/m$^3$**

c(650) m$^{-1}$

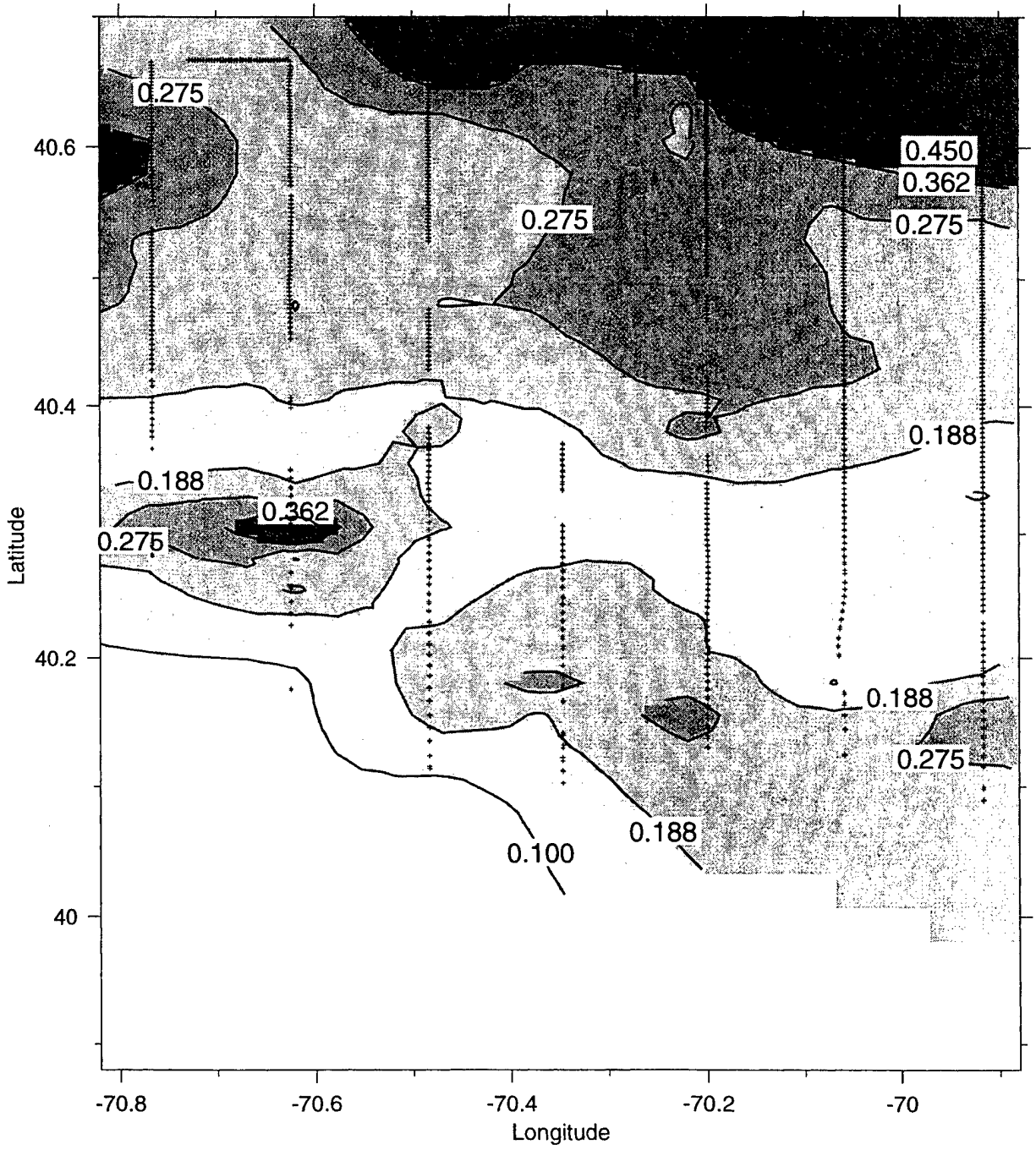


# E9704 Bigbox 1

04-May-97 12:42 to 06-May-97 20:22

**Map view at 10 m above bottom**

c(650) $m^{-1}$

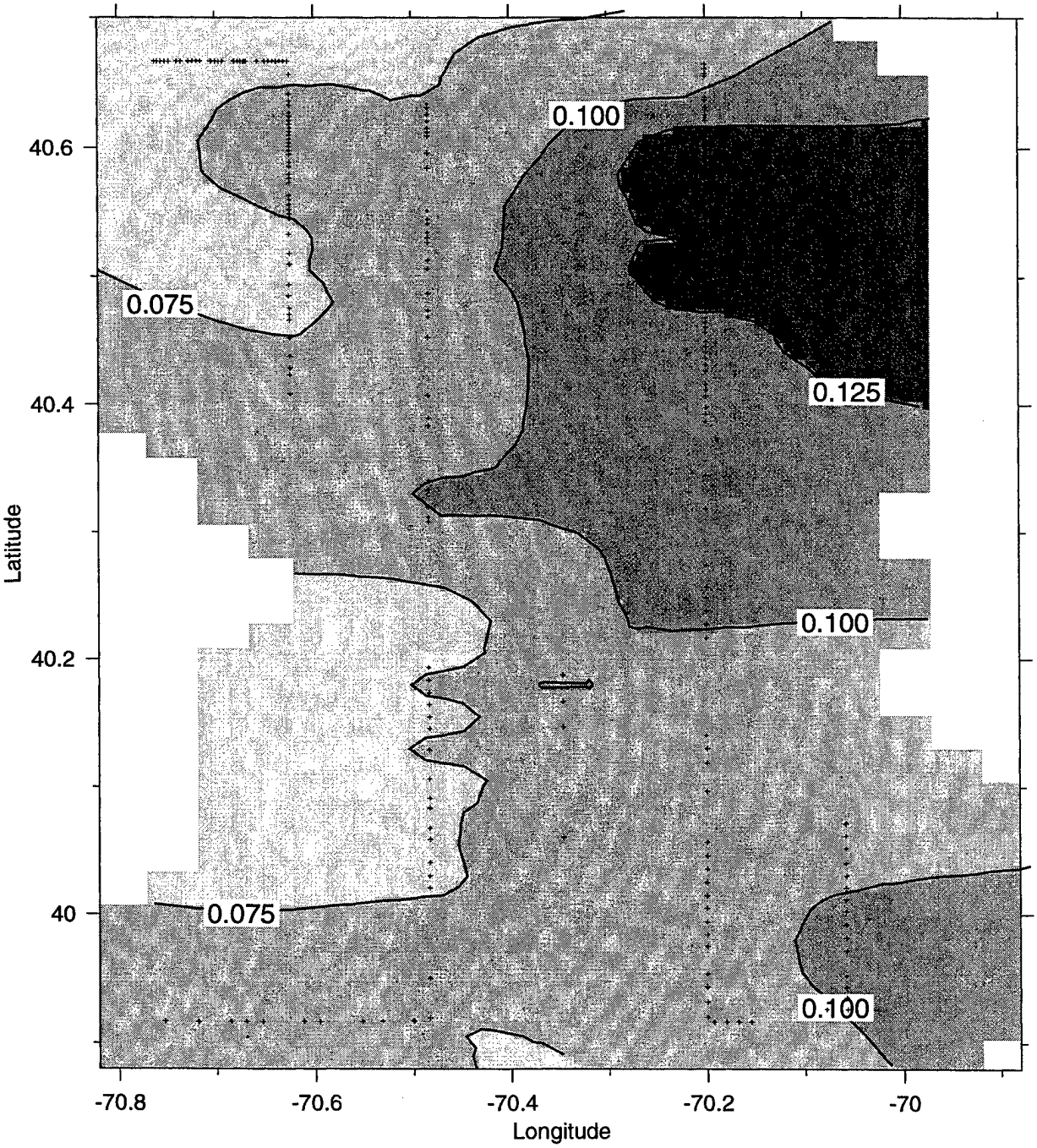


# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at 5 m**

a(676) $m^{-1}$

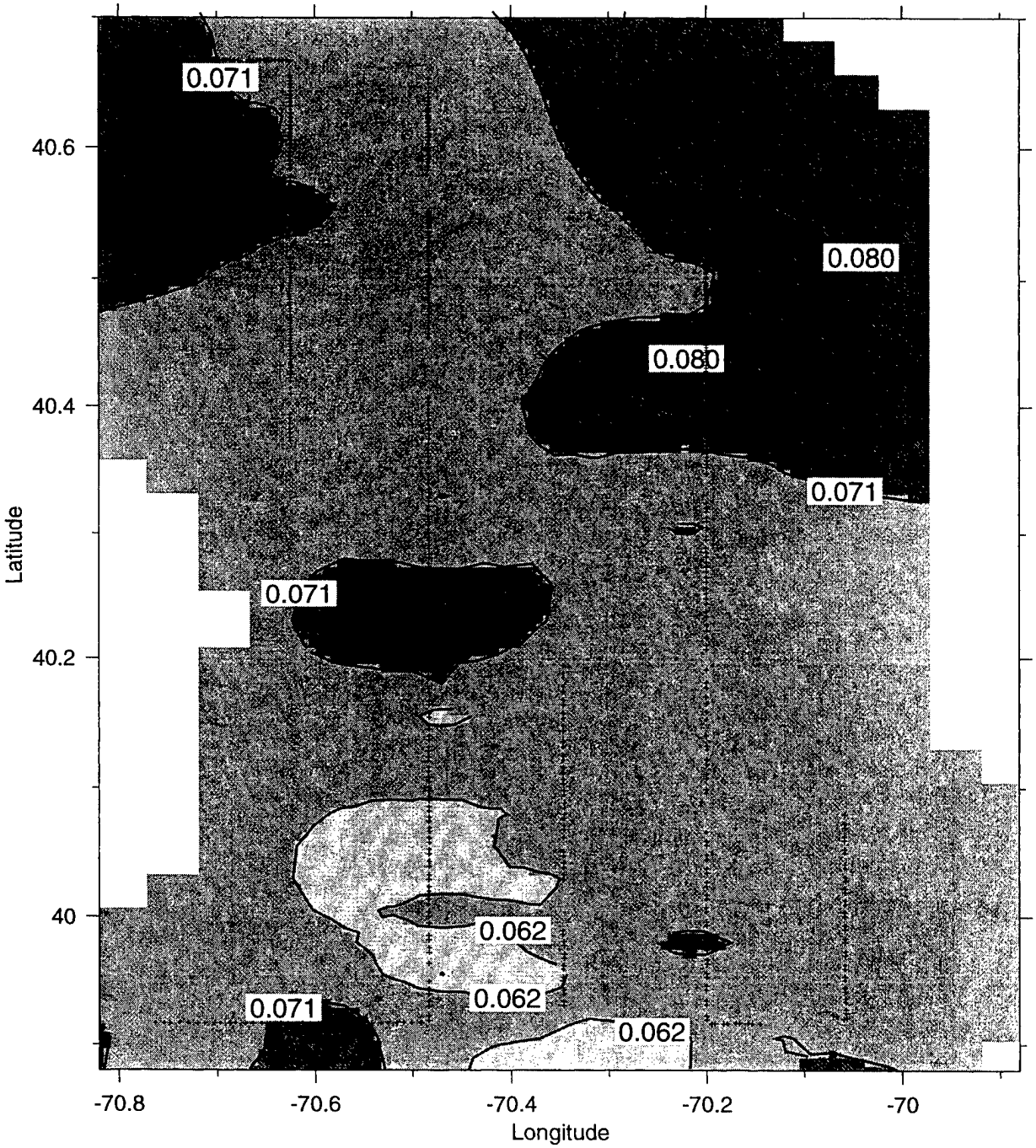


# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at 45 m**

a(676) $m^{-1}$

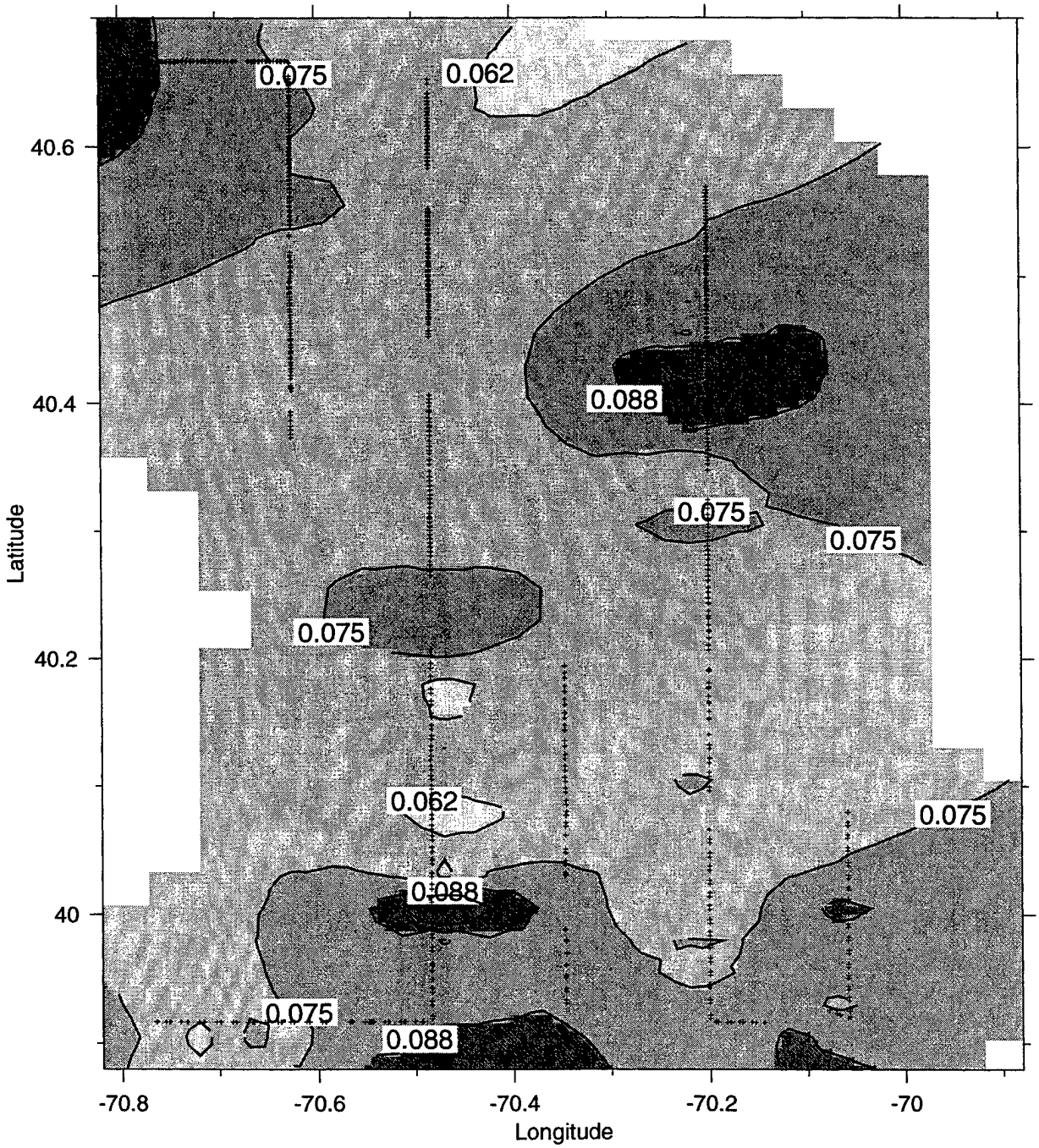


# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at $\sigma_t$ = 25.4 ± 0.025 kg/m$^3$**

a(676) m$^{-1}$

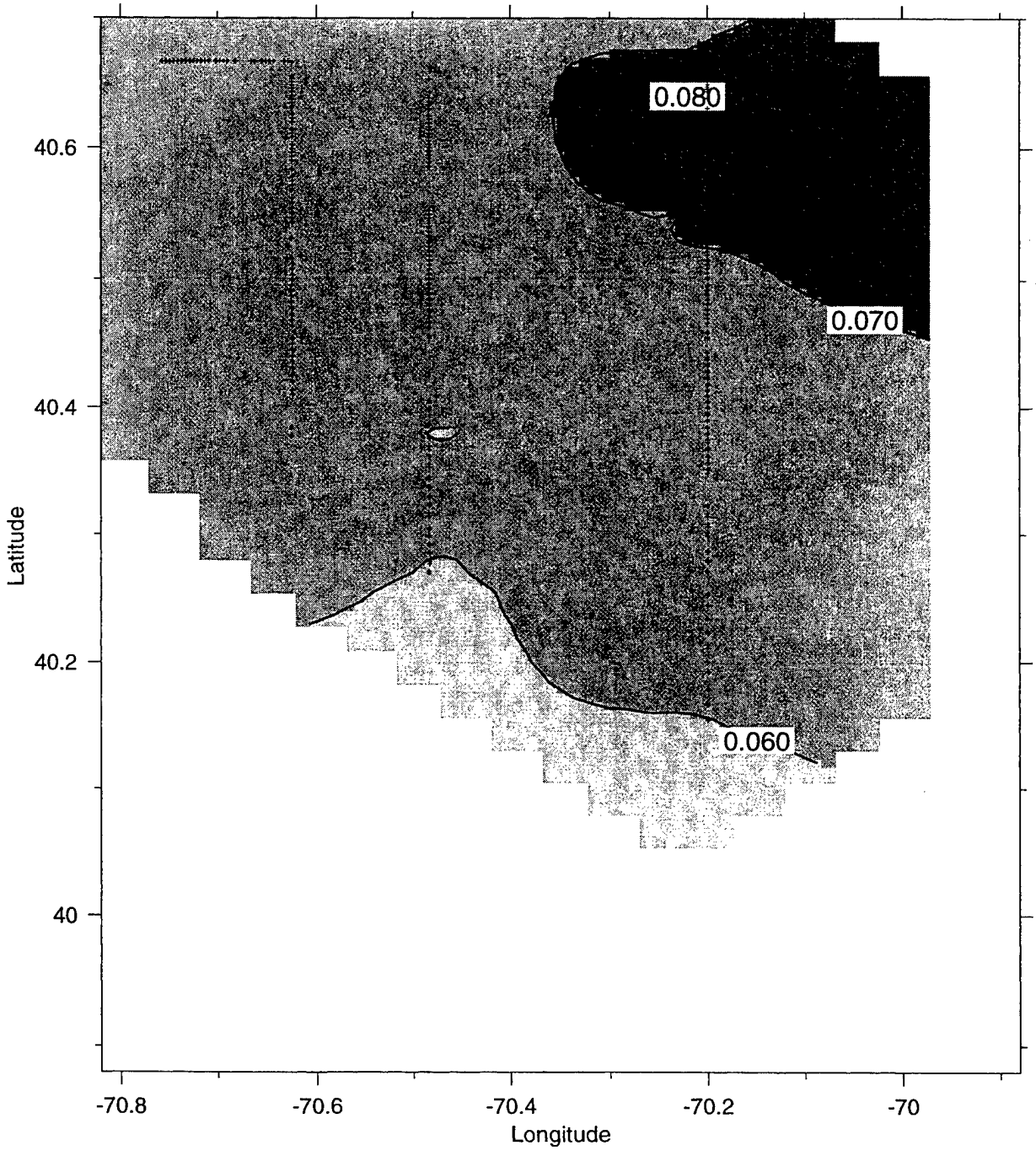


# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at 10 m above bottom**

a(676) $m^{-1}$

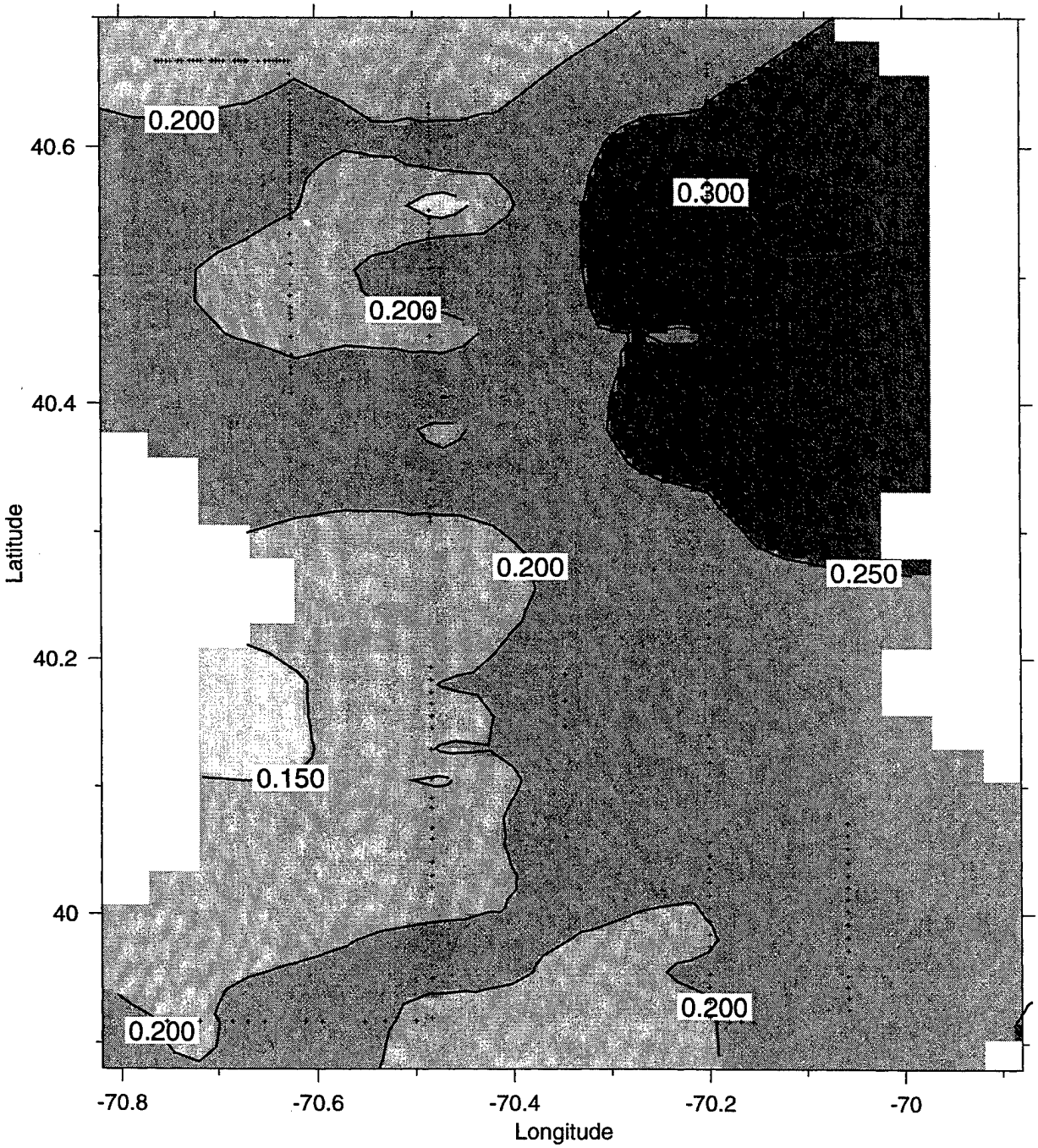


# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at 5 m**

a(440) $m^{-1}$

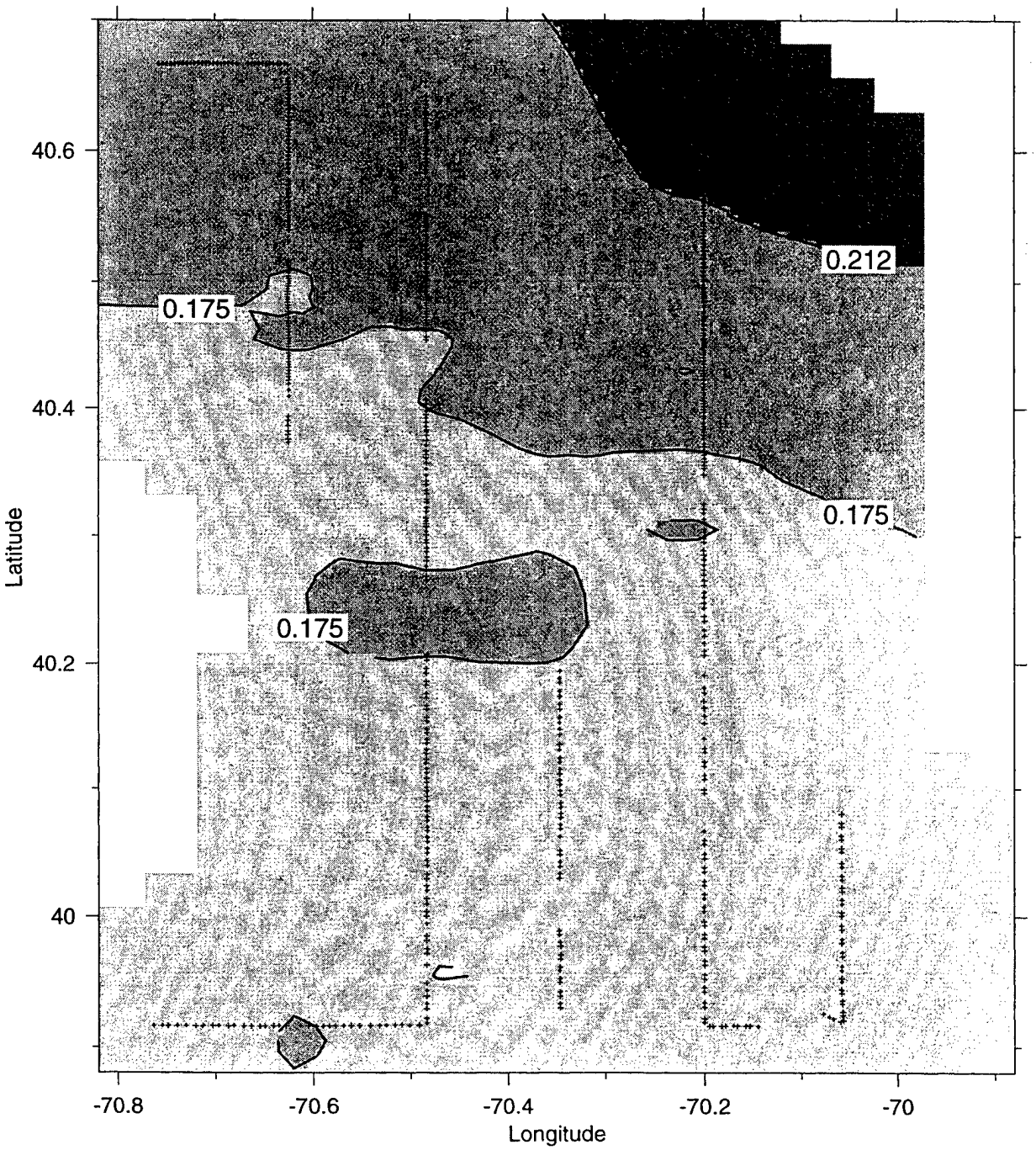


# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at 45 m**

a(440) $m^{-1}$

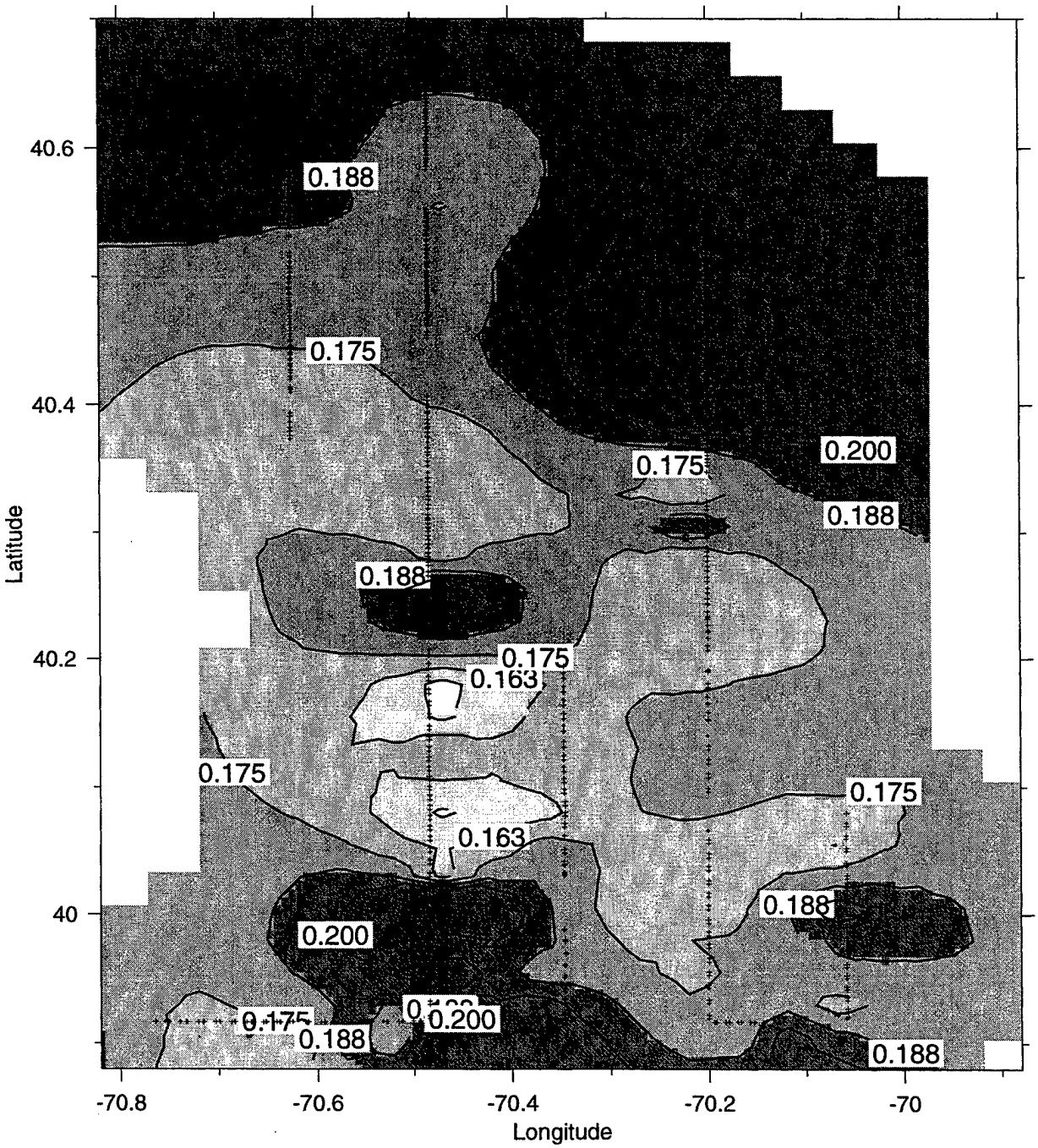


# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at $\sigma_t$ = 25.4 ± 0.025 kg/m$^3$**

a(440) m$^{-1}$

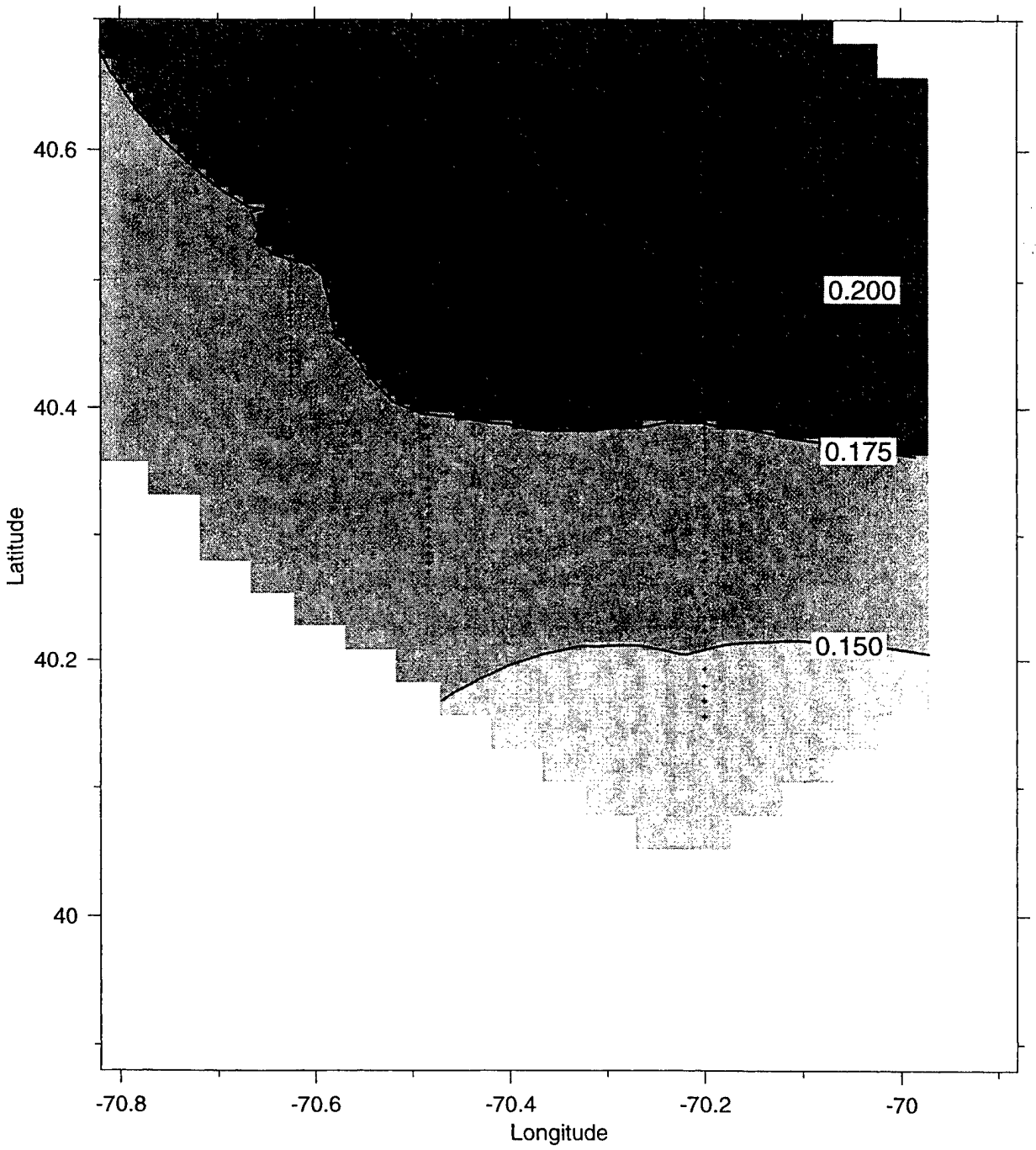


# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at 10 m above bottom**

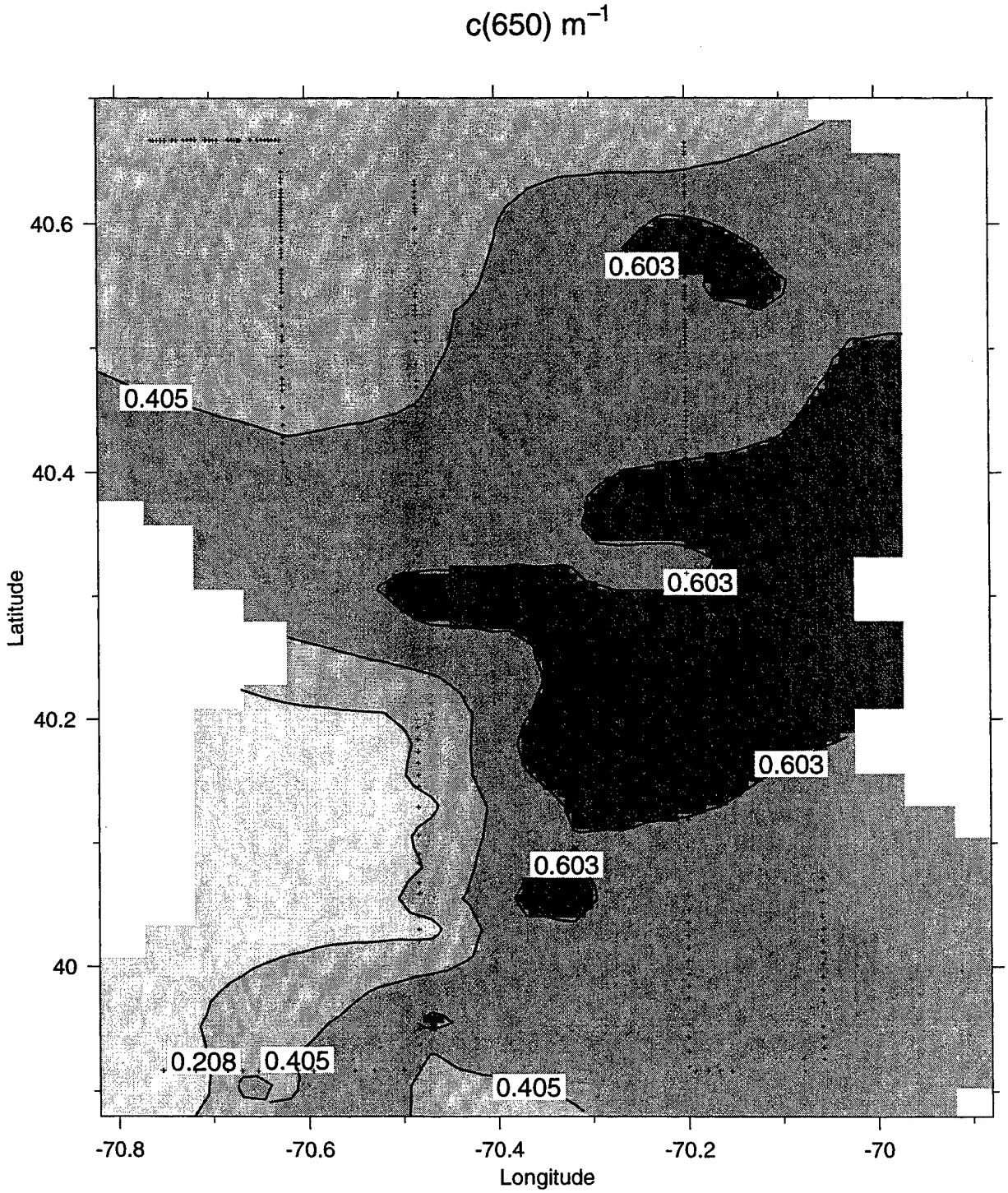
a(440) $m^{-1}$



# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at 5 m**

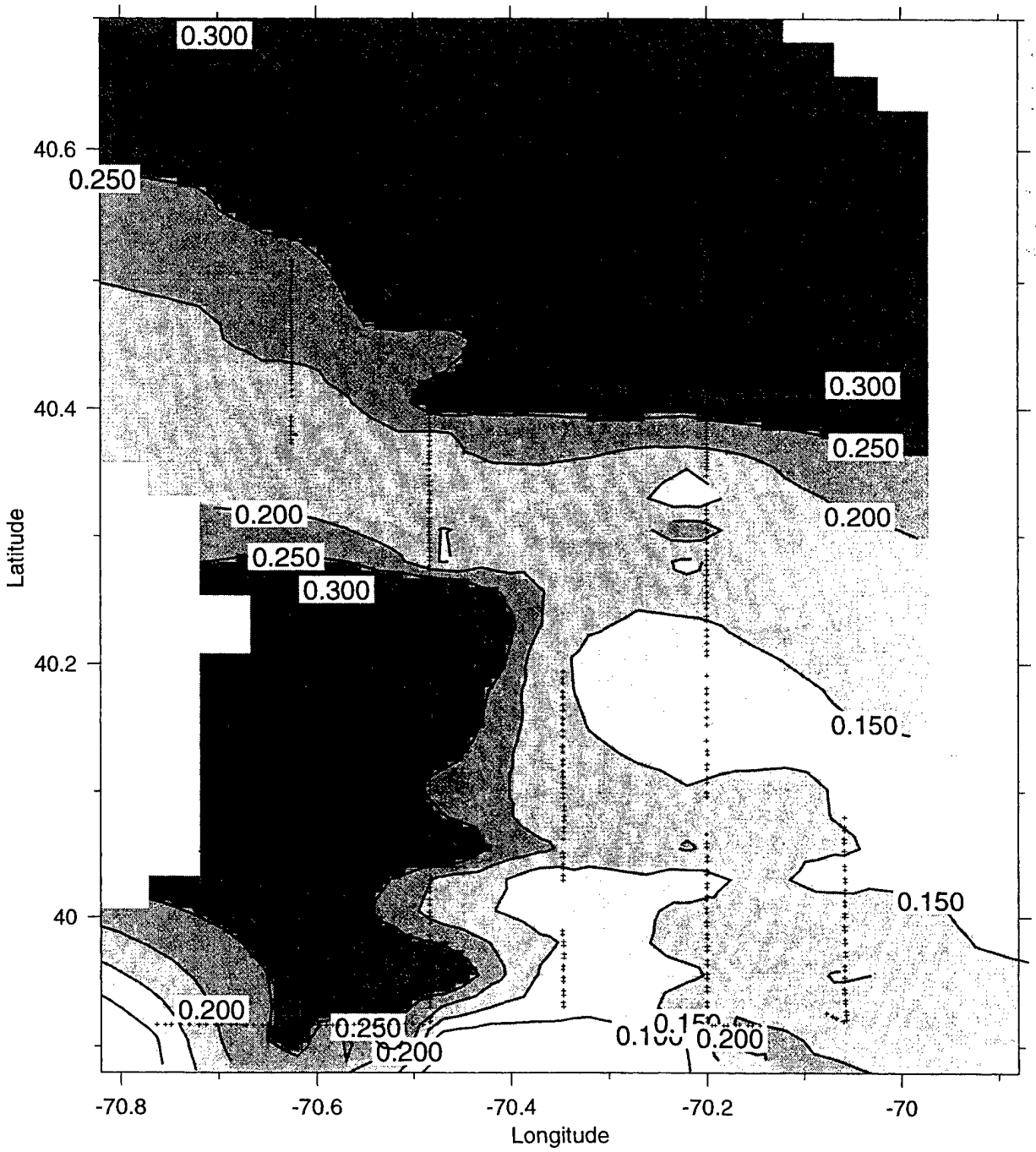


# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at 45 m**

c(650) $m^{-1}$

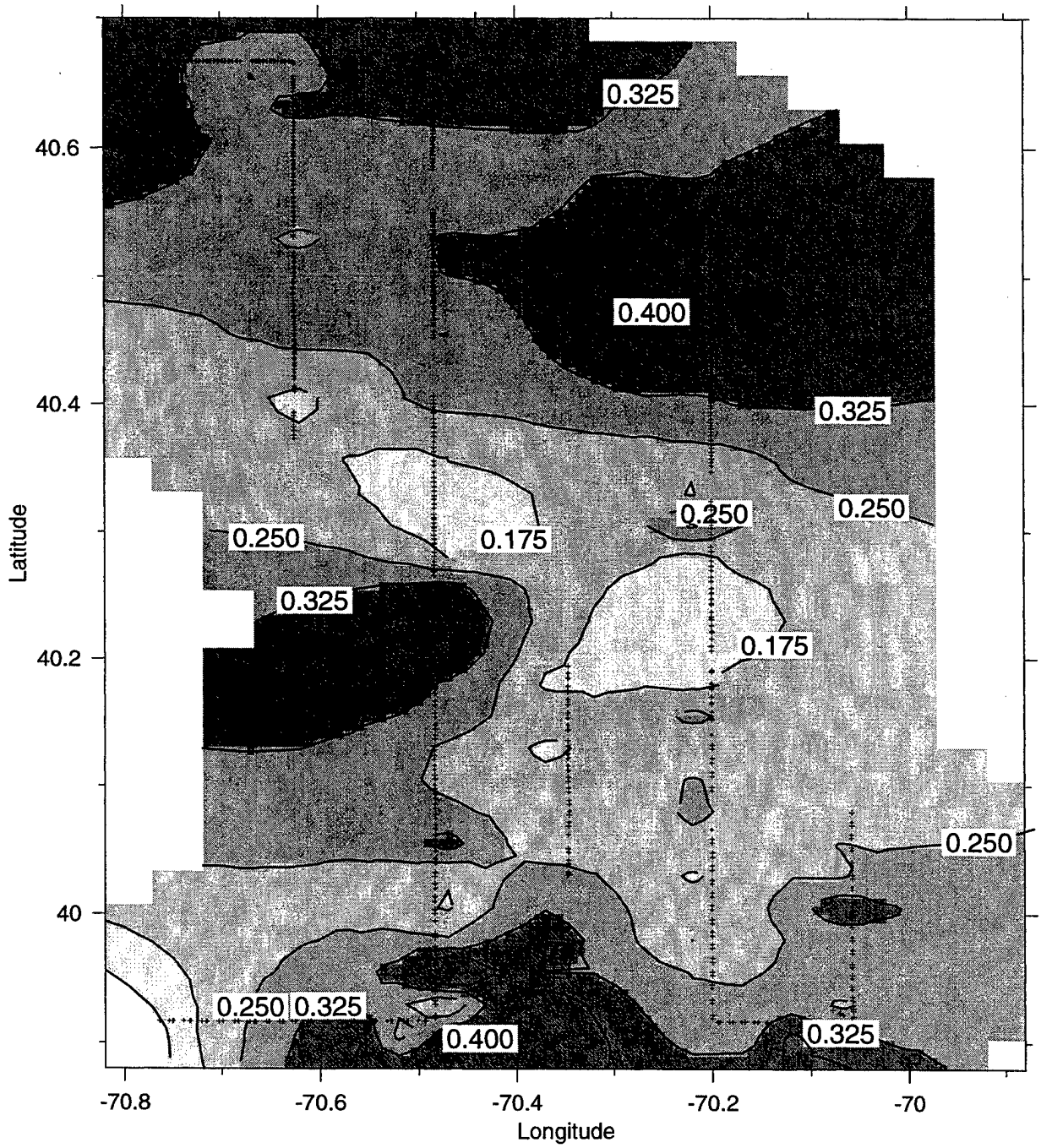


# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at $\sigma_t$ = 25.4 ± 0.025 kg/m$^3$**

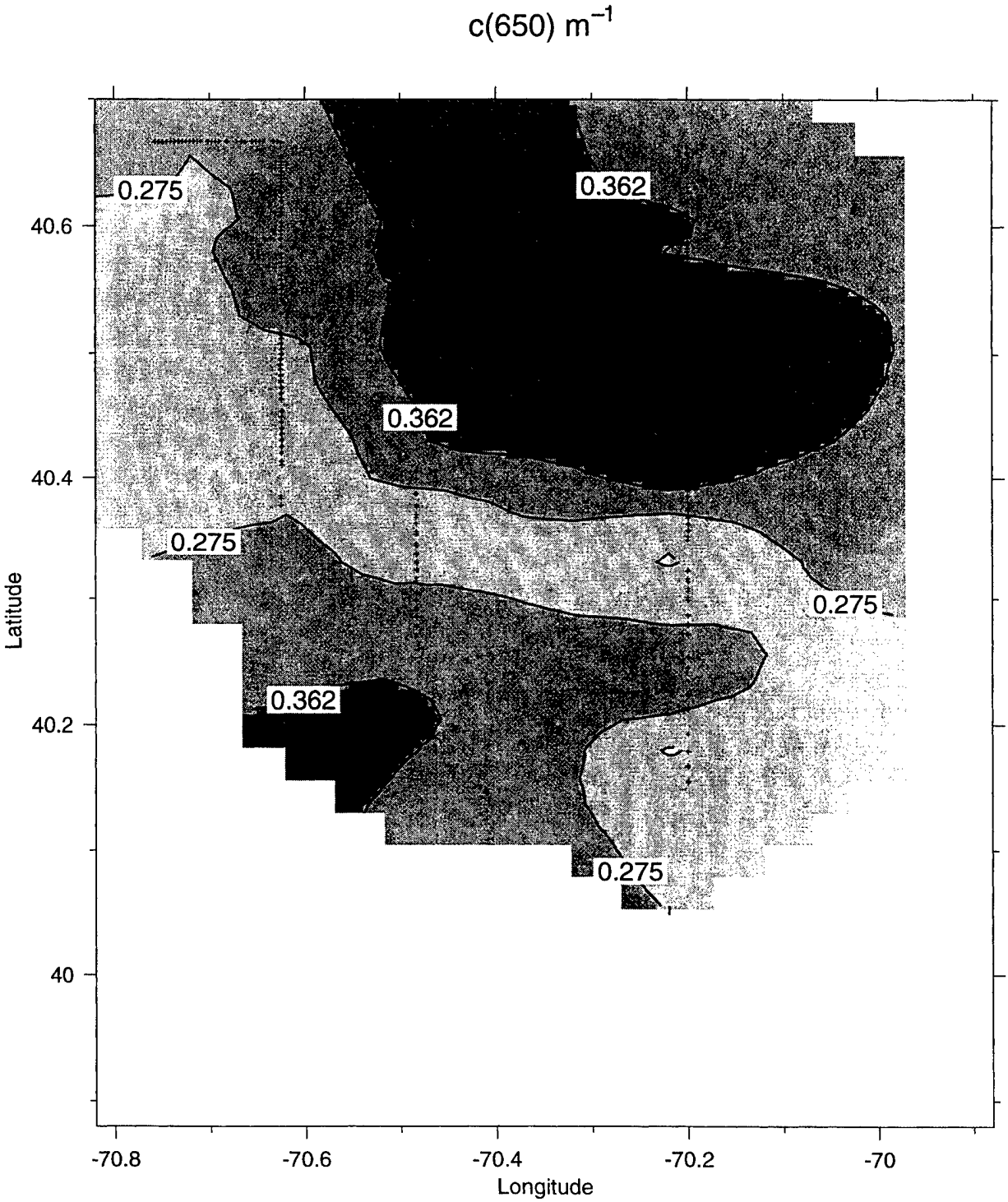
c(650) m$^{-1}$



# E9704 Bigbox 2

12-May-97 16:00 to 14-May-97 10:56

**Map view at 10 m above bottom**

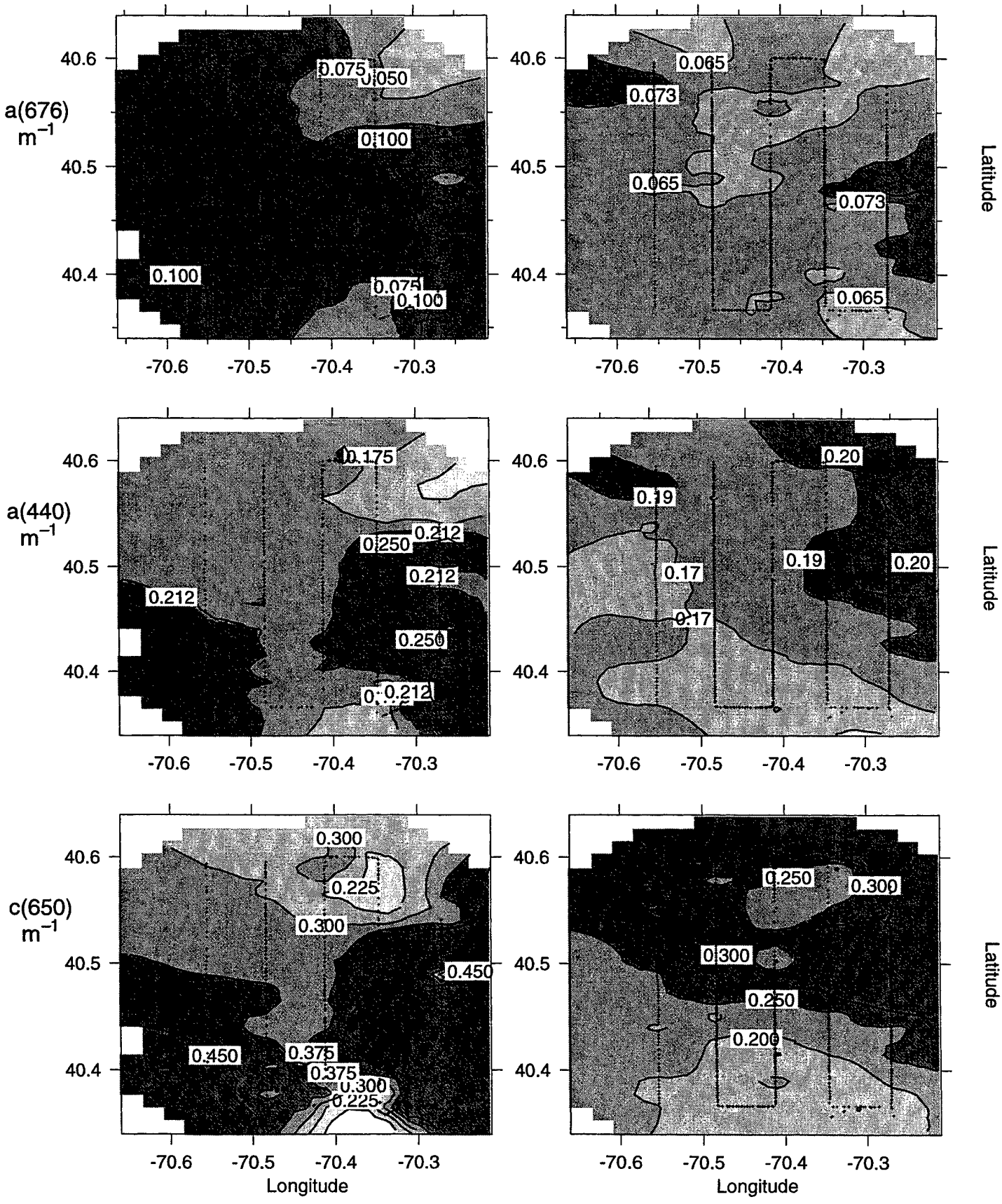


# E9704 Smallbox Maps

# E9704 Smallbox 1

27-Apr-97 01:18 to 12-May-97 12:25

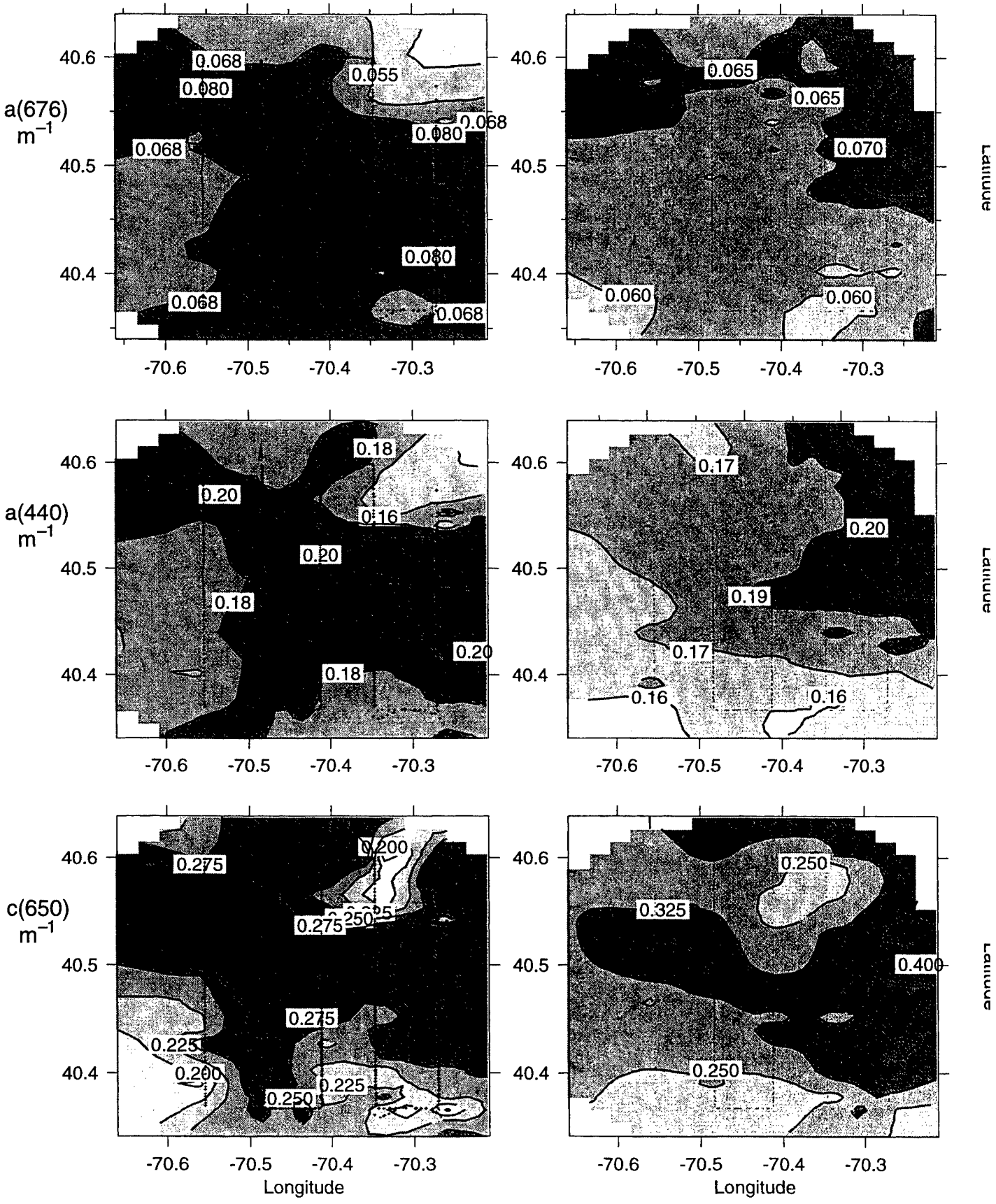
**Map view at 5 m** **Map view at 45 m**



# E9704 Smallbox 1

27-Apr-97 01:18 to 12-May-97 12:25

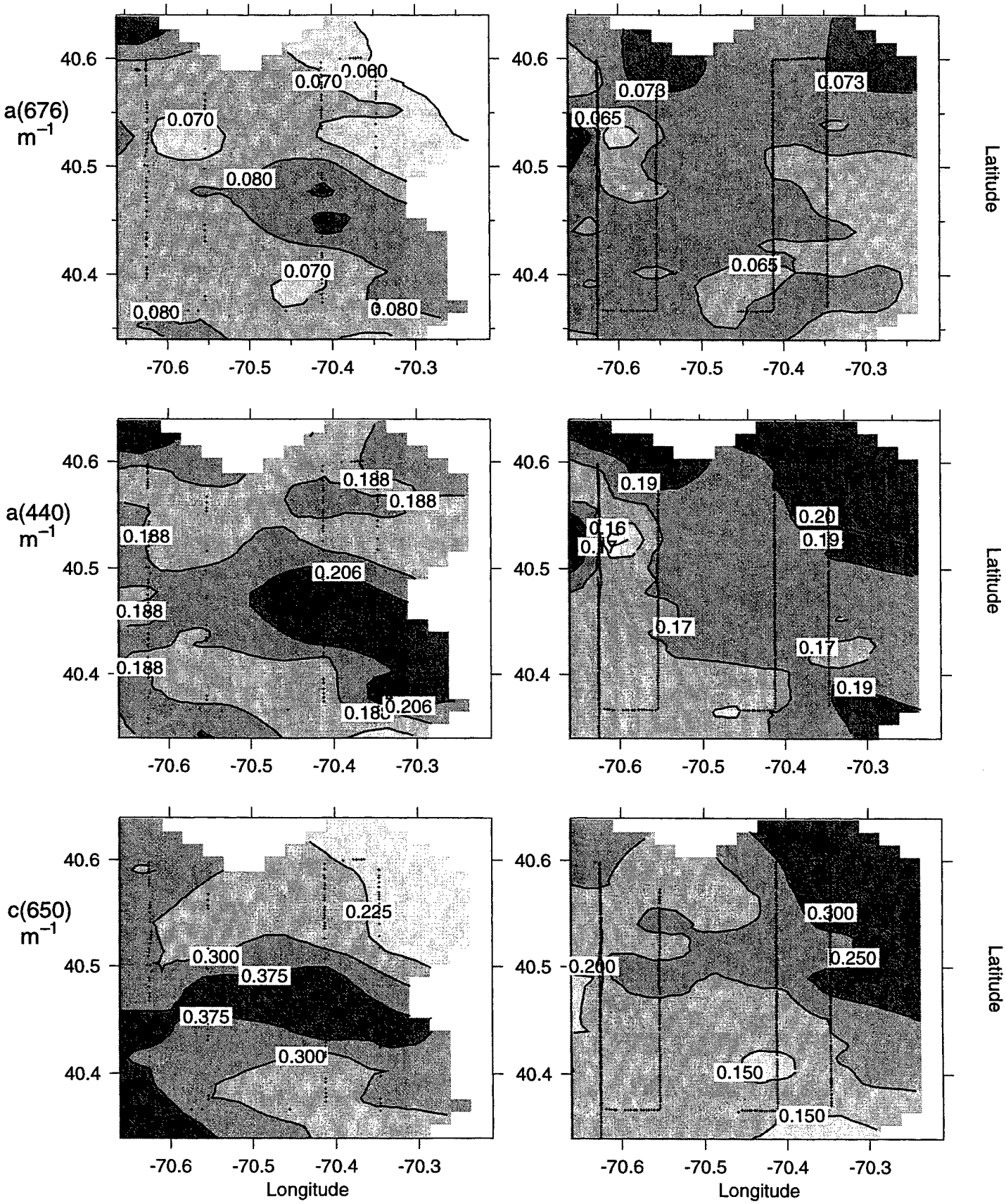
**Map view at $\sigma_t = 25.4 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**



# E9704 Smallbox 2

27-Apr-97 22:28 to 28-Apr-97 14:36

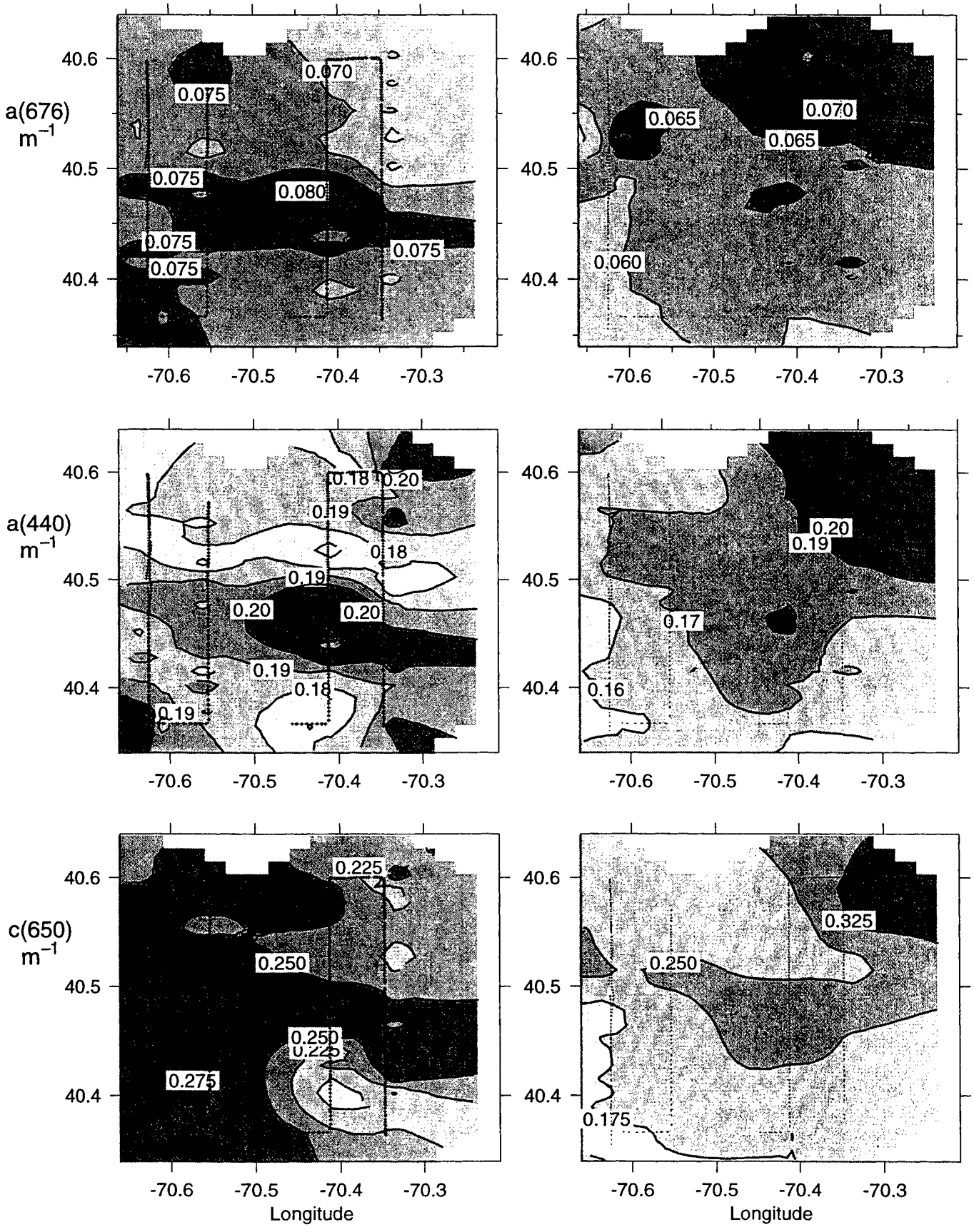
**Map view at 5 m** **Map view at 45 m**



# E9704 Smallbox 2

27-Apr-97 22:28 to 28-Apr-97 14:36

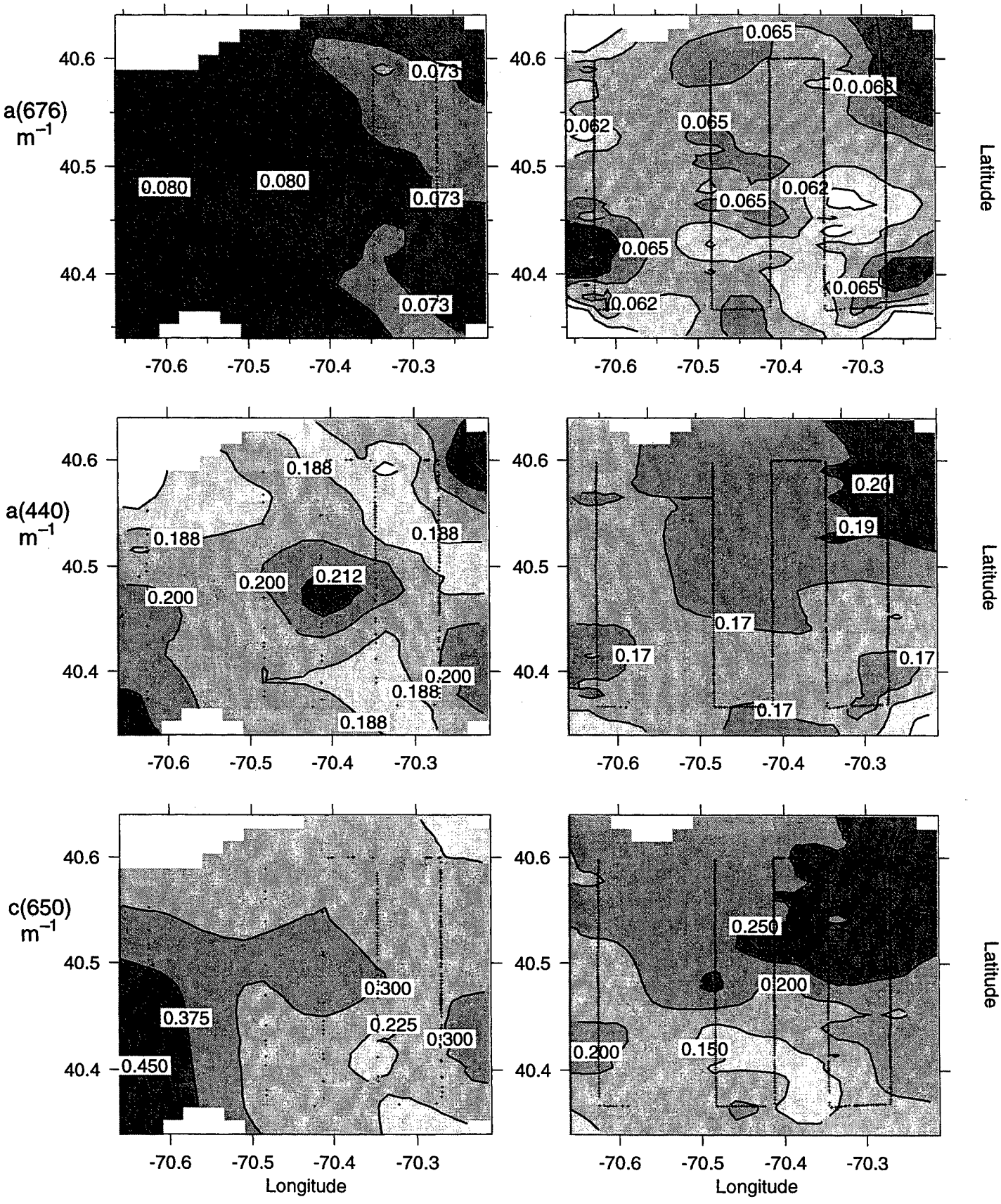
**Map view at $\sigma_t$ = 25.4 ± 0.025 kg/m$^3$** **Map view at 10 m above the bottom**



# E9704 Smallbox 3

29-Apr-97 01:16 to 29-Apr-97 20:50

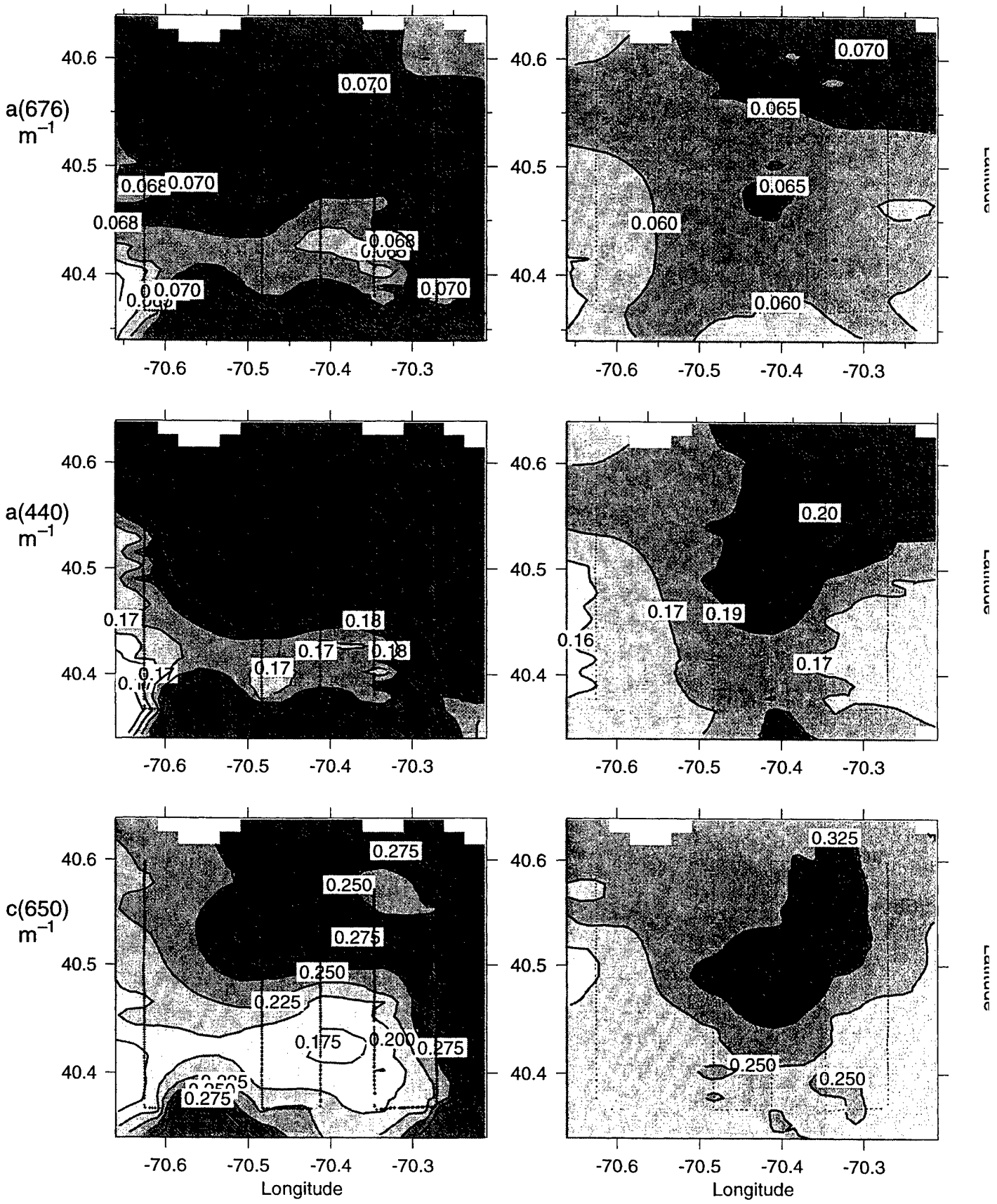
**Map view at 5 m** **Map view at 45 m**



# E9704 Smallbox 3

29-Apr-97 01:16 to 29-Apr-97 20:50

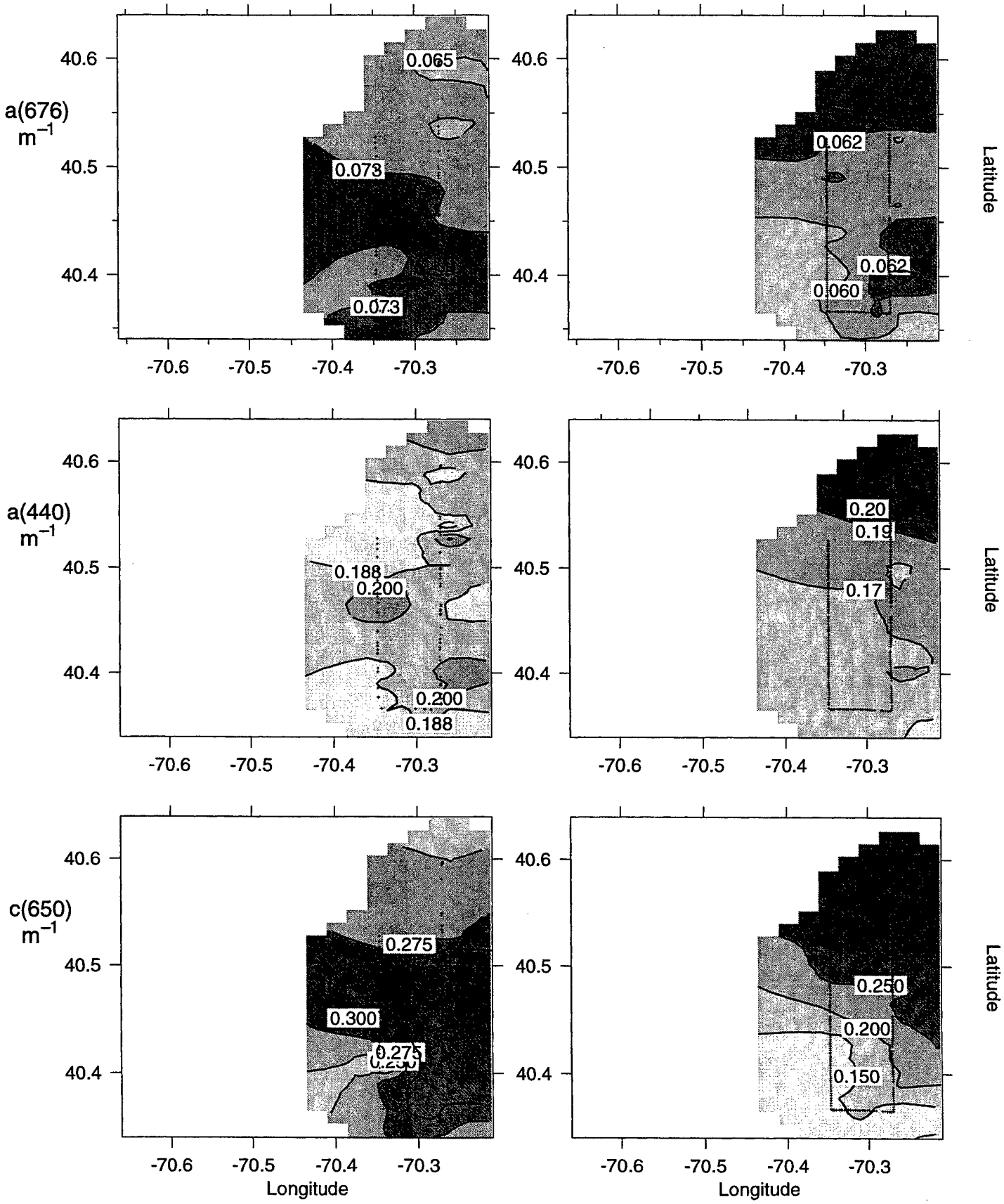
**Map view at $\sigma_t$ = 25.4 ± 0.025 kg/m$^3$** **Map view at 10 m above the bottom**



# E9704 Smallbox 4

29-Apr-97 20:54 to 30-Apr-97 00:54

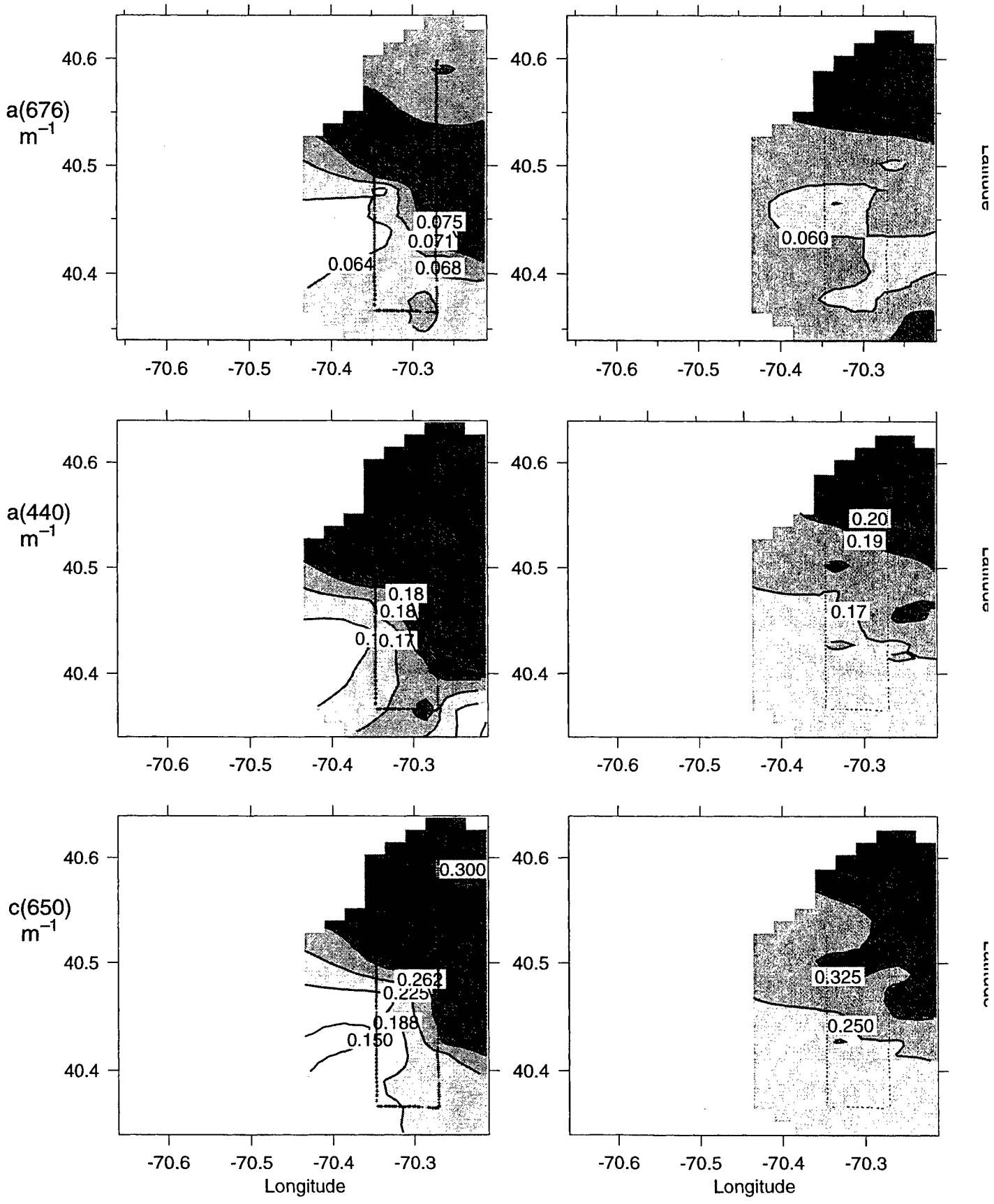
**Map view at 5 m** **Map view at 45 m**



# E9704 Smallbox 4

29-Apr-97 20:54 to 30-Apr-97 00:54

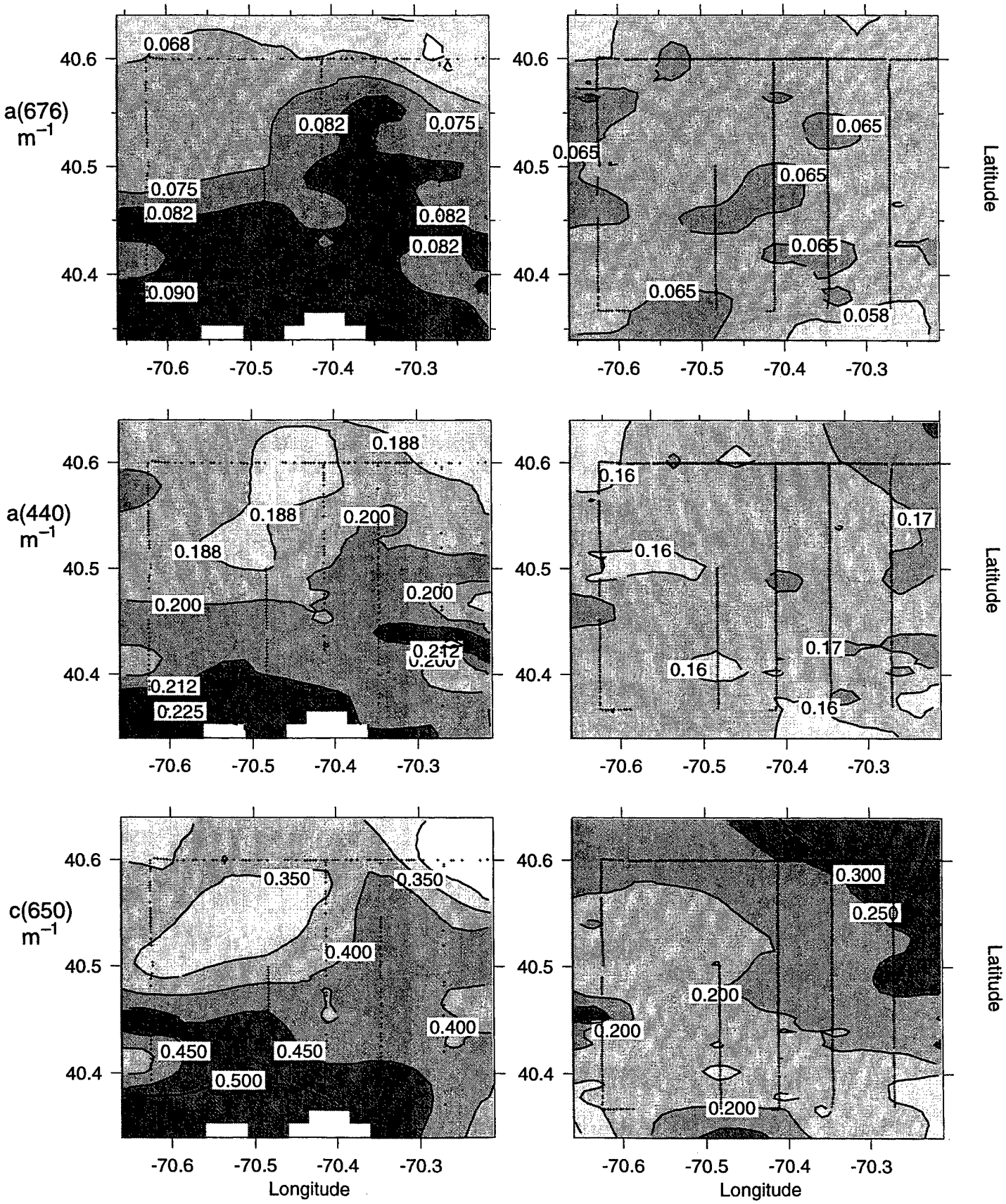
**Map view at $\sigma_t = 25.4 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**



# E9704 Smallbox 5

02-May-97 12:40 to 03-May-97 11:44

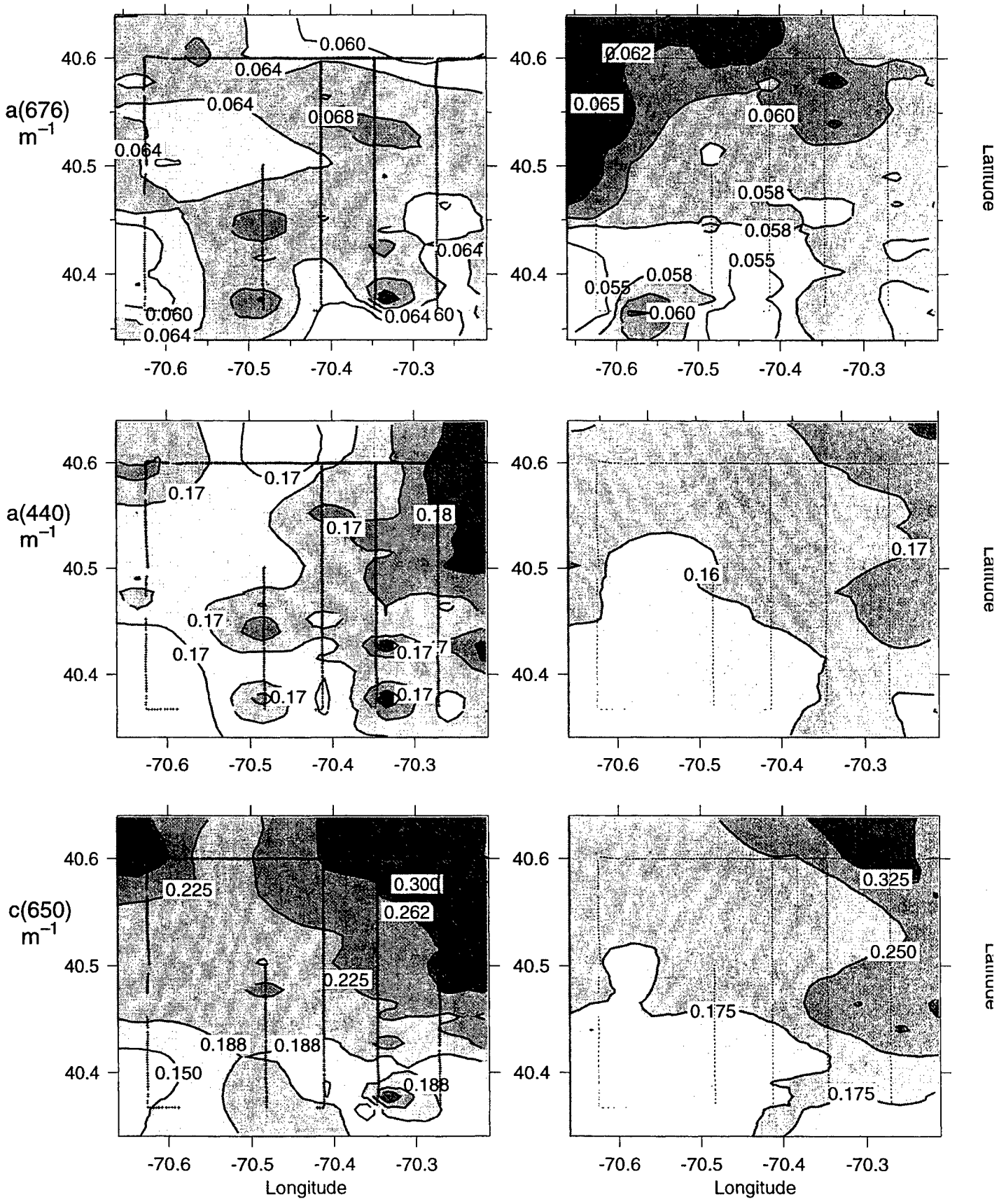
**Map view at 5 m** **Map view at 45 m**



# E9704 Smallbox 5

02-May-97 12:40 to 03-May-97 11:44

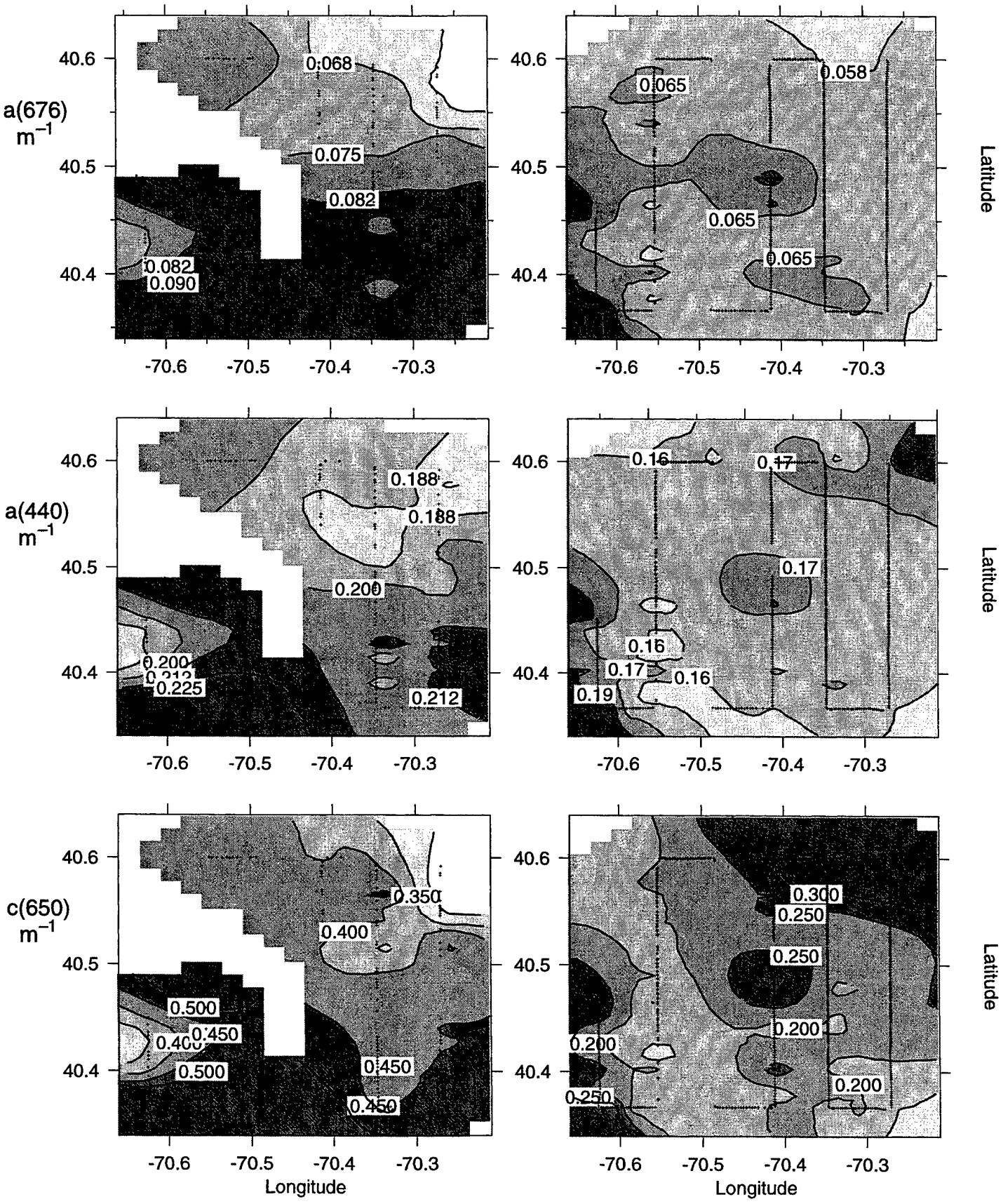
**Map view at $\sigma_t = 25.4 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**



# E9704 Smallbox 6

03-May-97 11:45 to 04-May-97 02:08

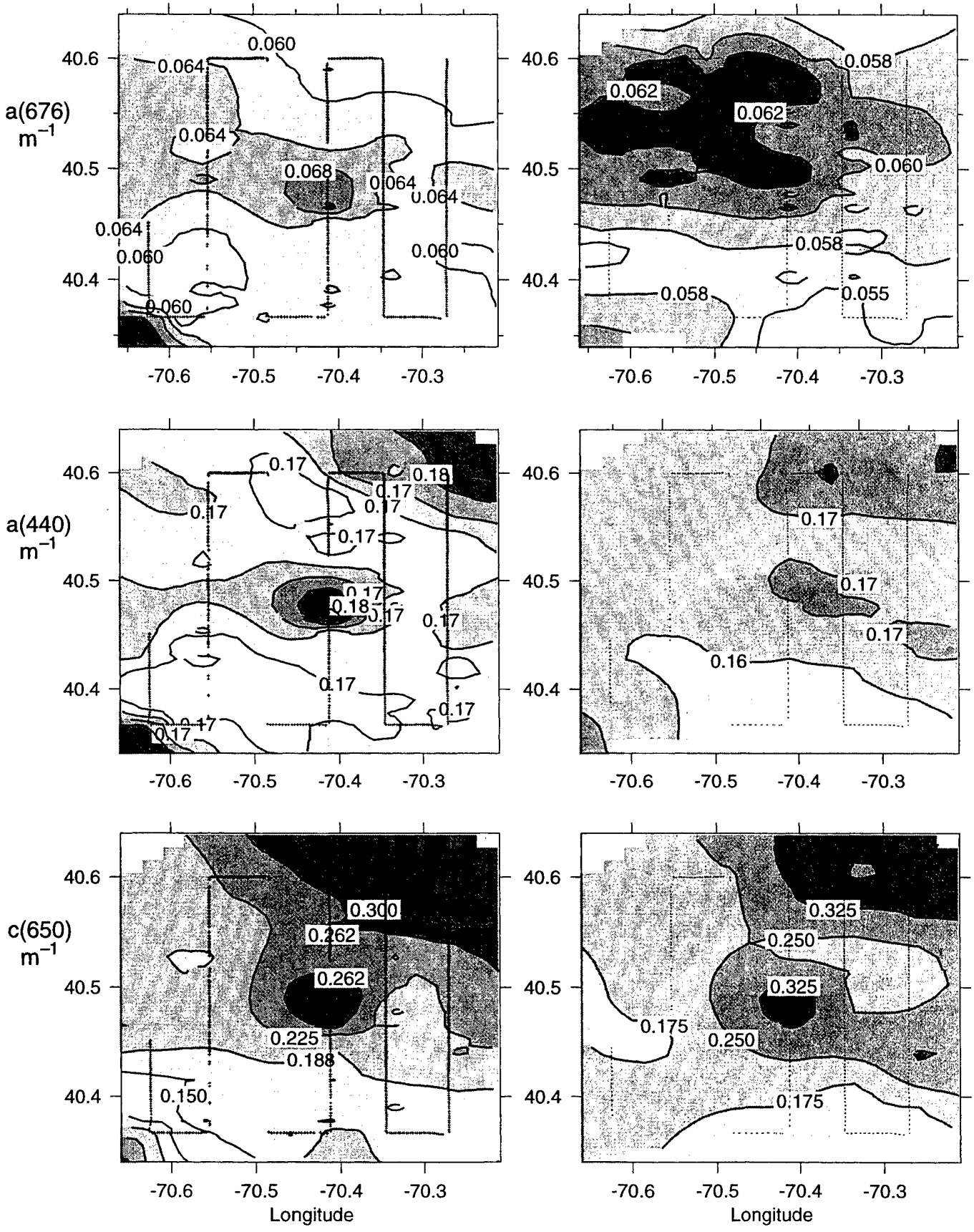
**Map view at 5 m** **Map view at 45 m**



# E9704 Smallbox 6

03-May-97 11:45 to 04-May-97 02:08

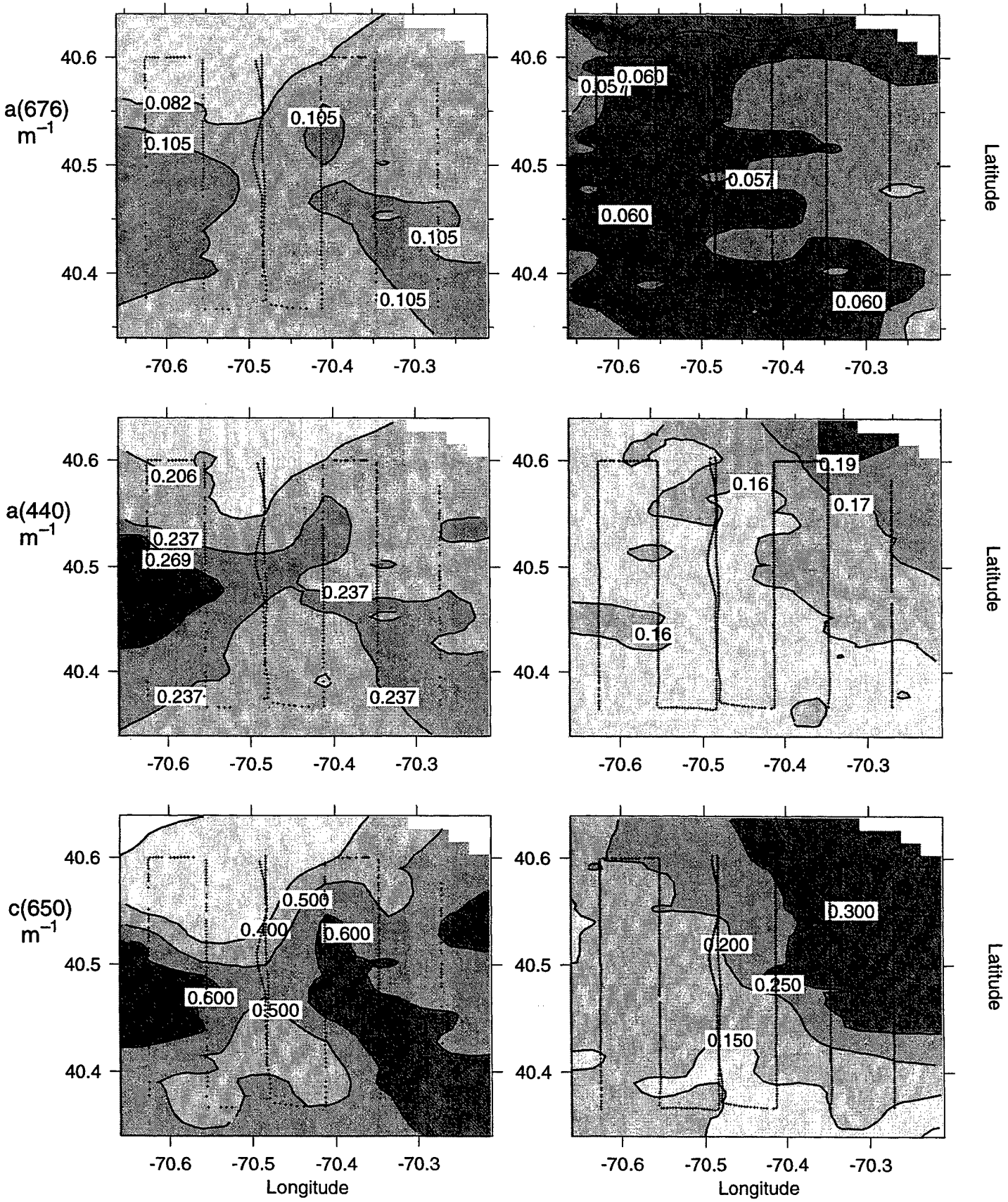
**Map view at $\sigma_t = 25.4 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**



# E9704 Smallbox 7

06-May-97 20:42 to 07-May-97 13:50

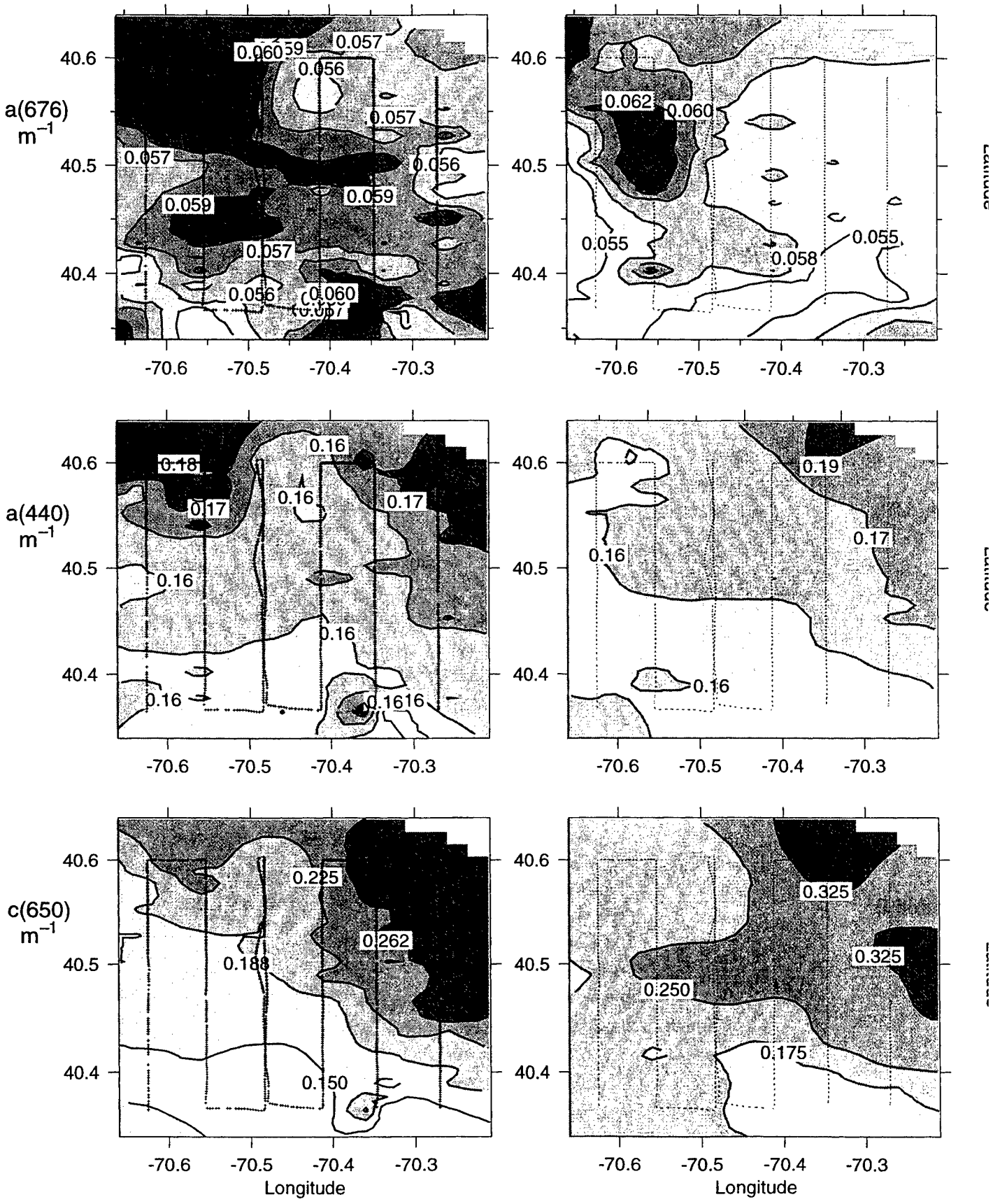
**Map view at 5 m** **Map view at 45 m**



# E9704 Smallbox 7

06-May-97 20:42 to 07-May-97 13:50

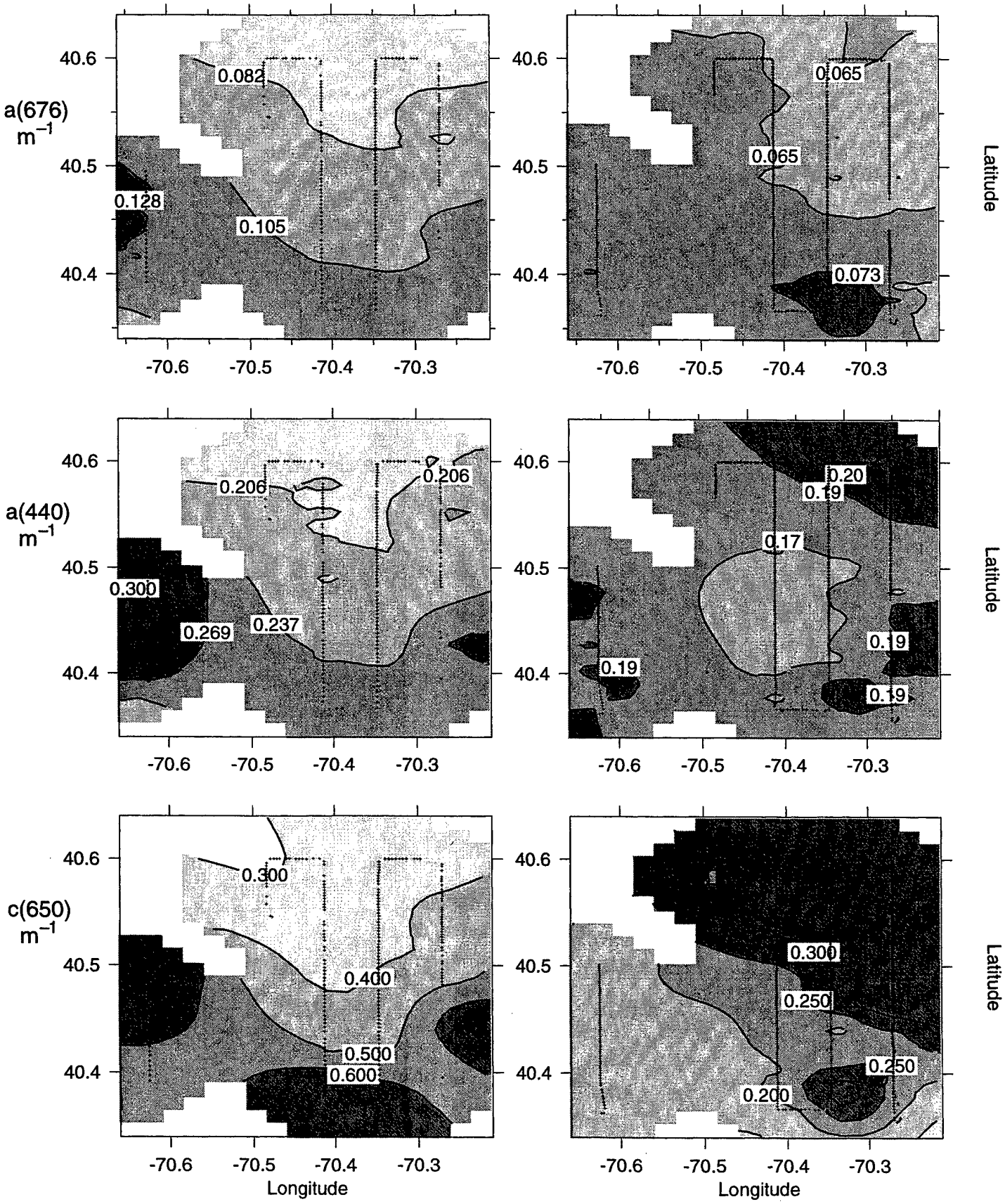
**Map view at $\sigma_t = 25.4 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**



# E9704 Smallbox 8

07-May-97 13:50 to 08-May-97 13:04

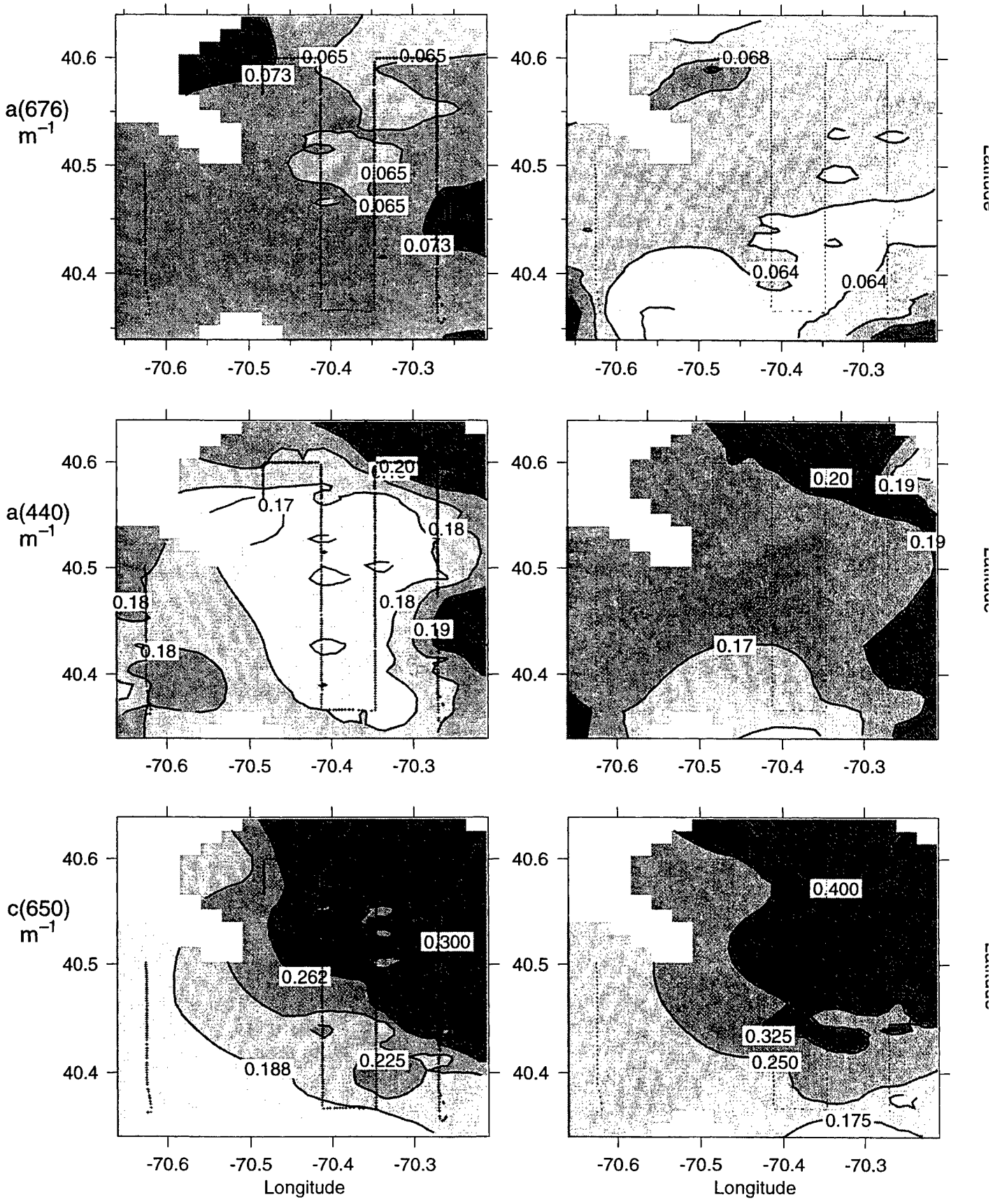
**Map view at 5 m** **Map view at 45 m**



# E9704 Smallbox 8

07-May-97 13:50 to 08-May-97 13:04

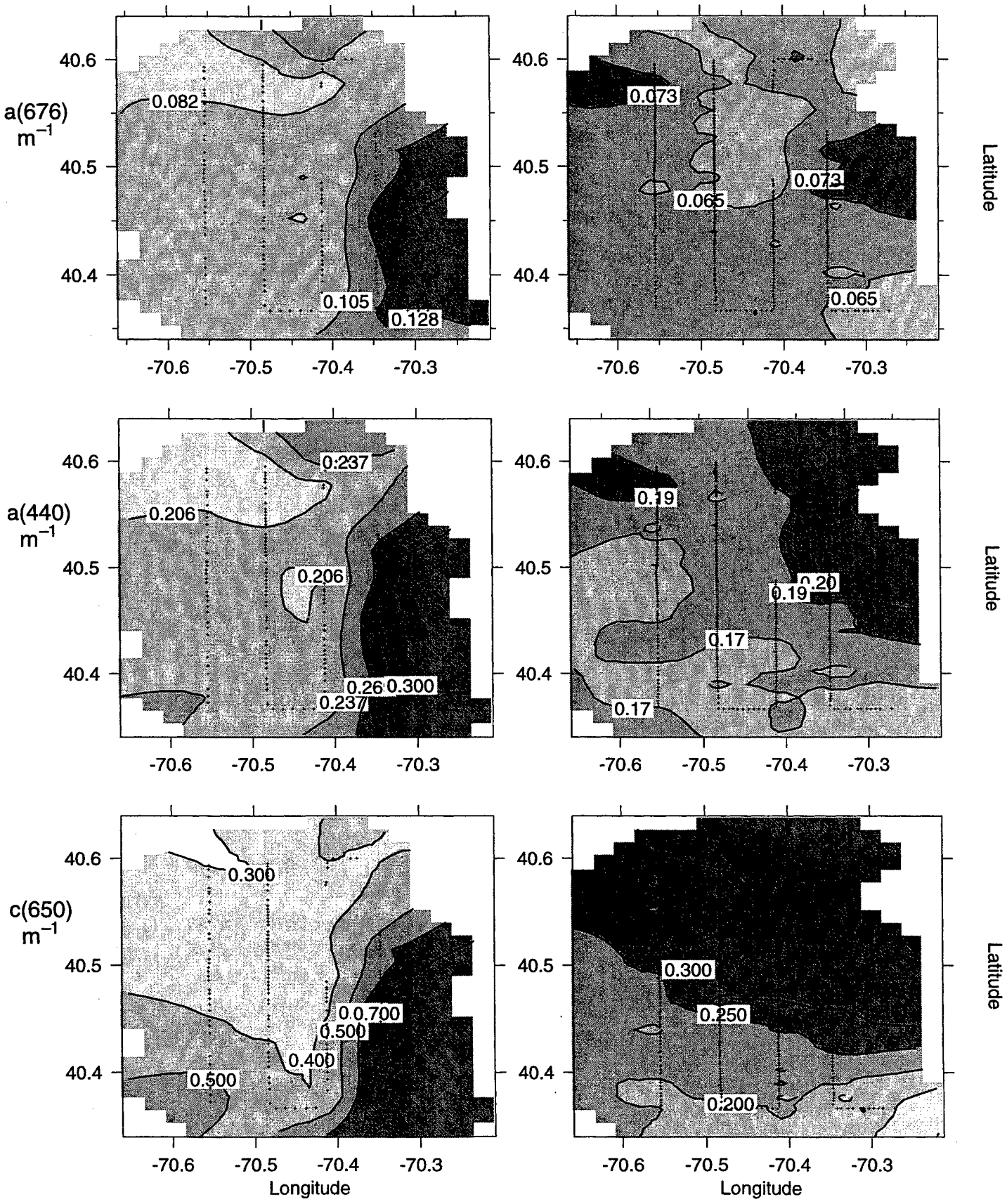
**Map view at $\sigma_t = 25.4 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**



# E9704 Smallbox 12

12-May-97 02:08 to 12-May-97 12:25

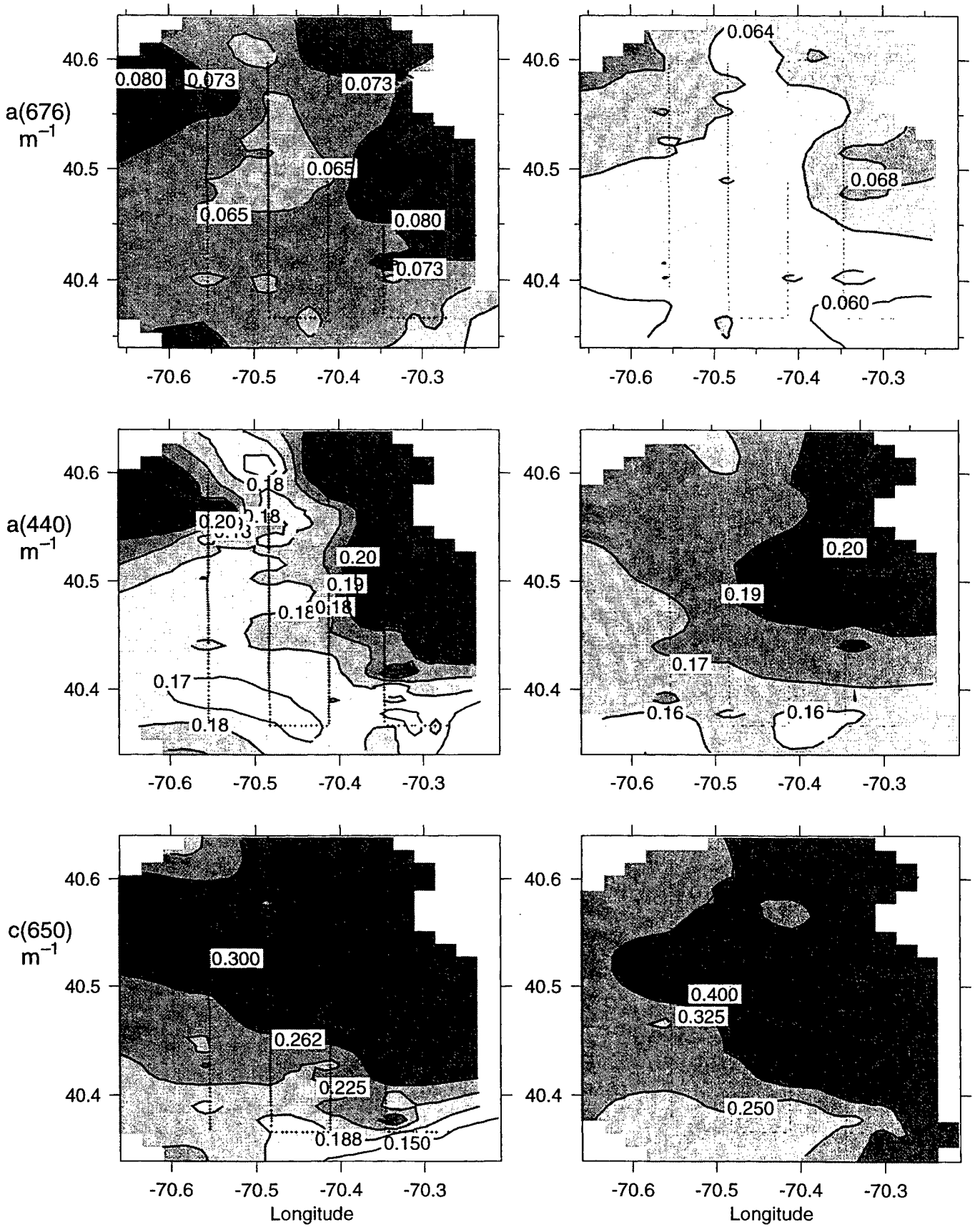
**Map view at 5 m** **Map view at 45 m**



# E9704 Smallbox 12

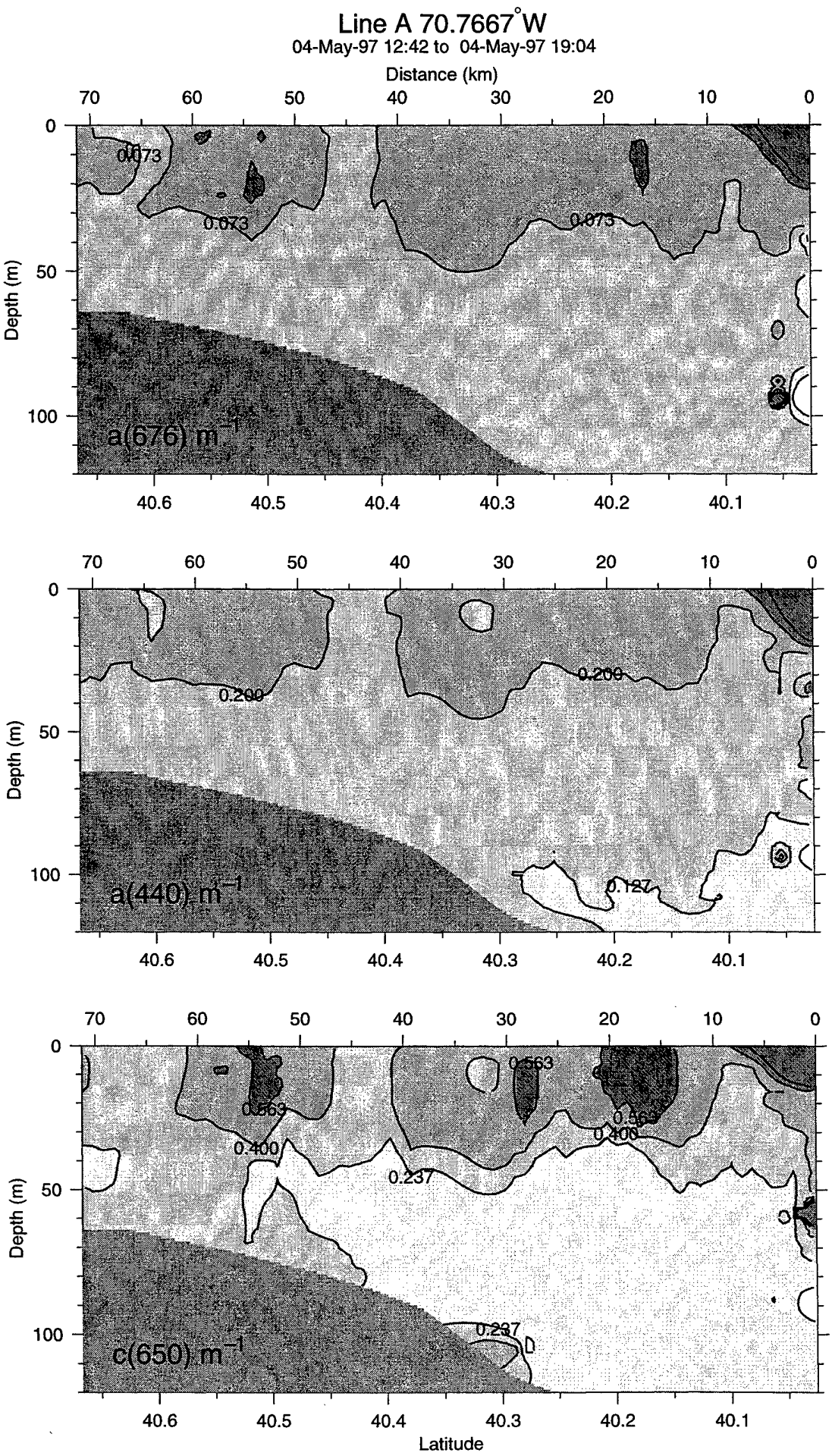
12-May-97 02:08 to 12-May-97 12:25

**Map view at $\sigma_t = 25.4 \pm 0.025$ kg/m$^3$** **Map view at 10 m above the bottom**

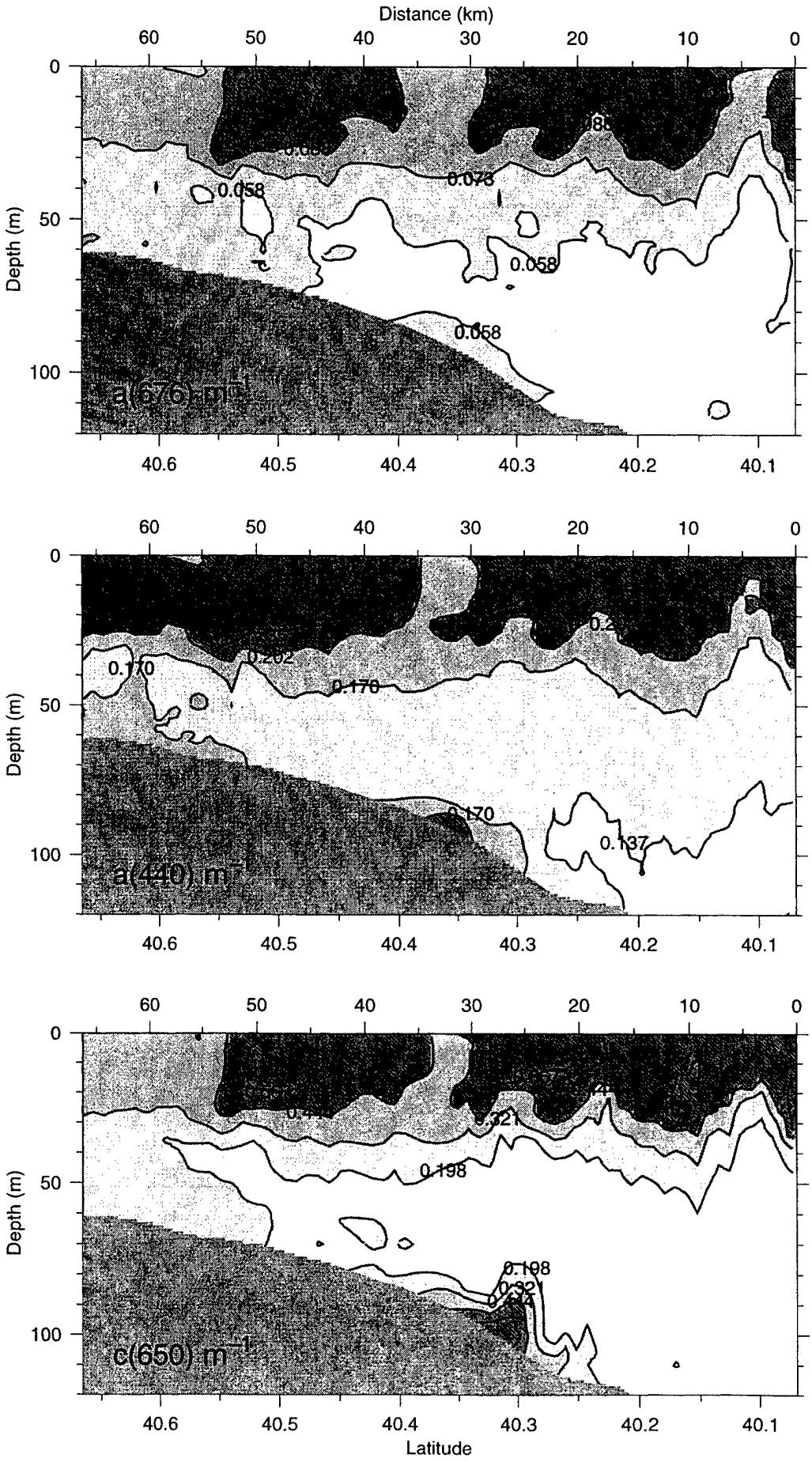


# E9704 Bigbox Sections

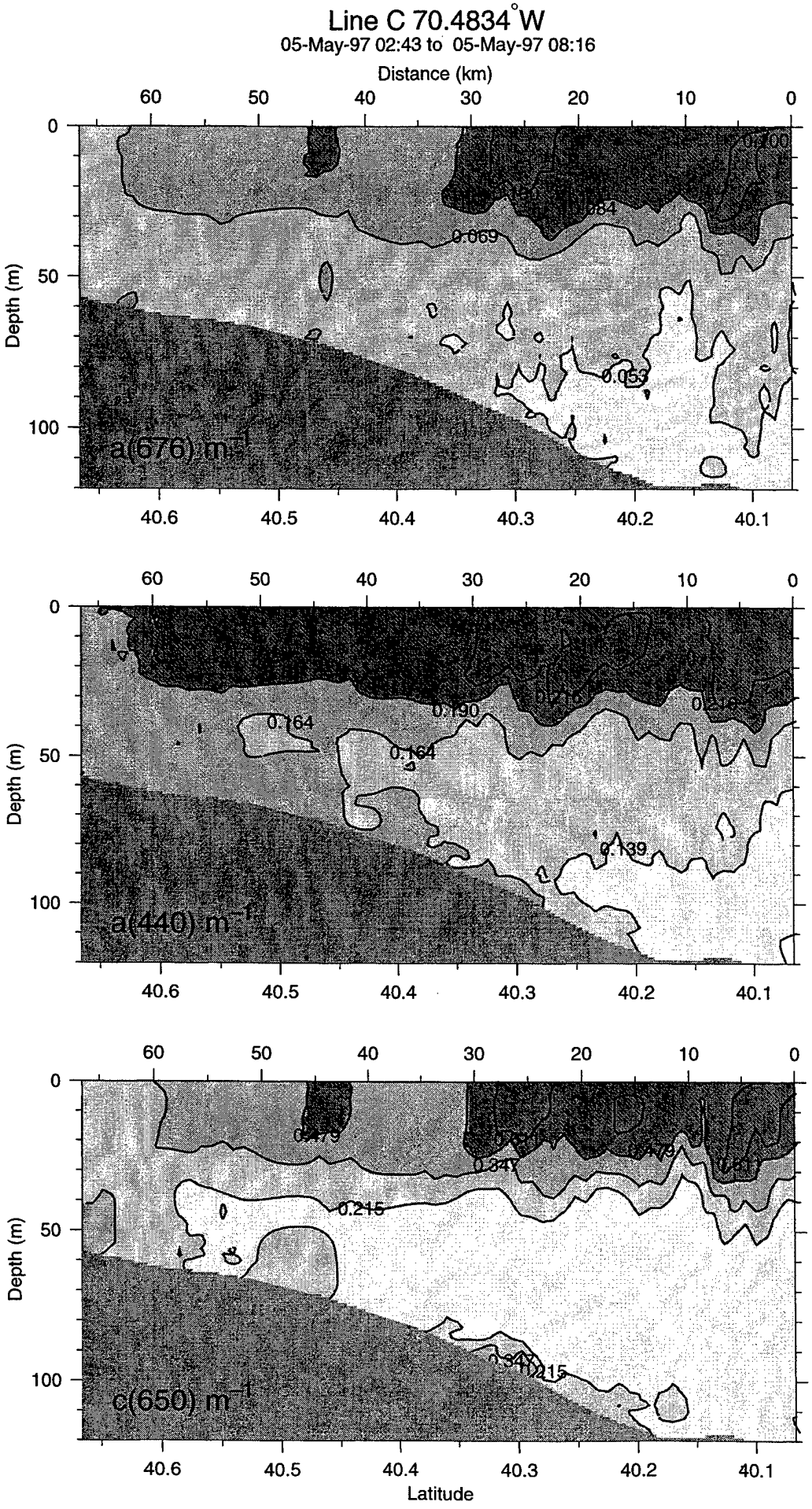
# E9704 Bigbox 1



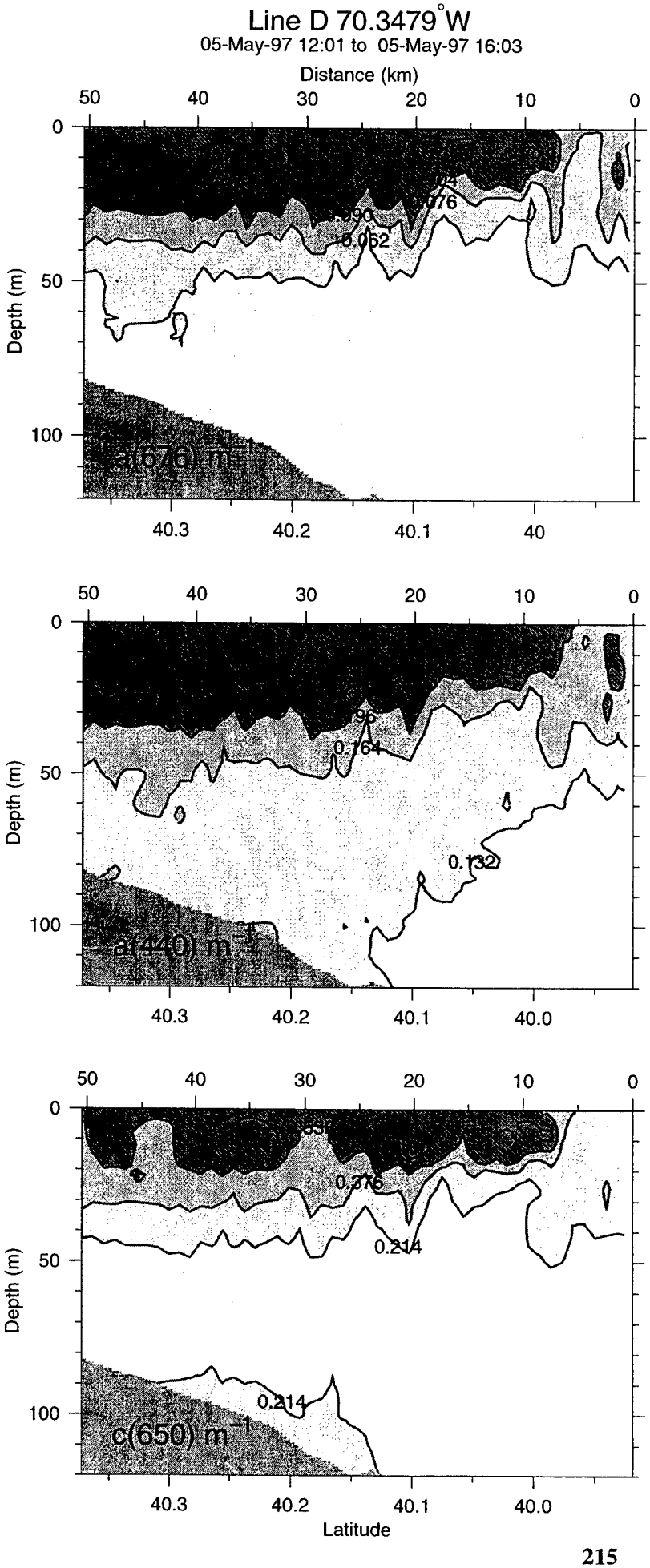
# E9704 Bigbox 1



# E9704 Bigbox 1



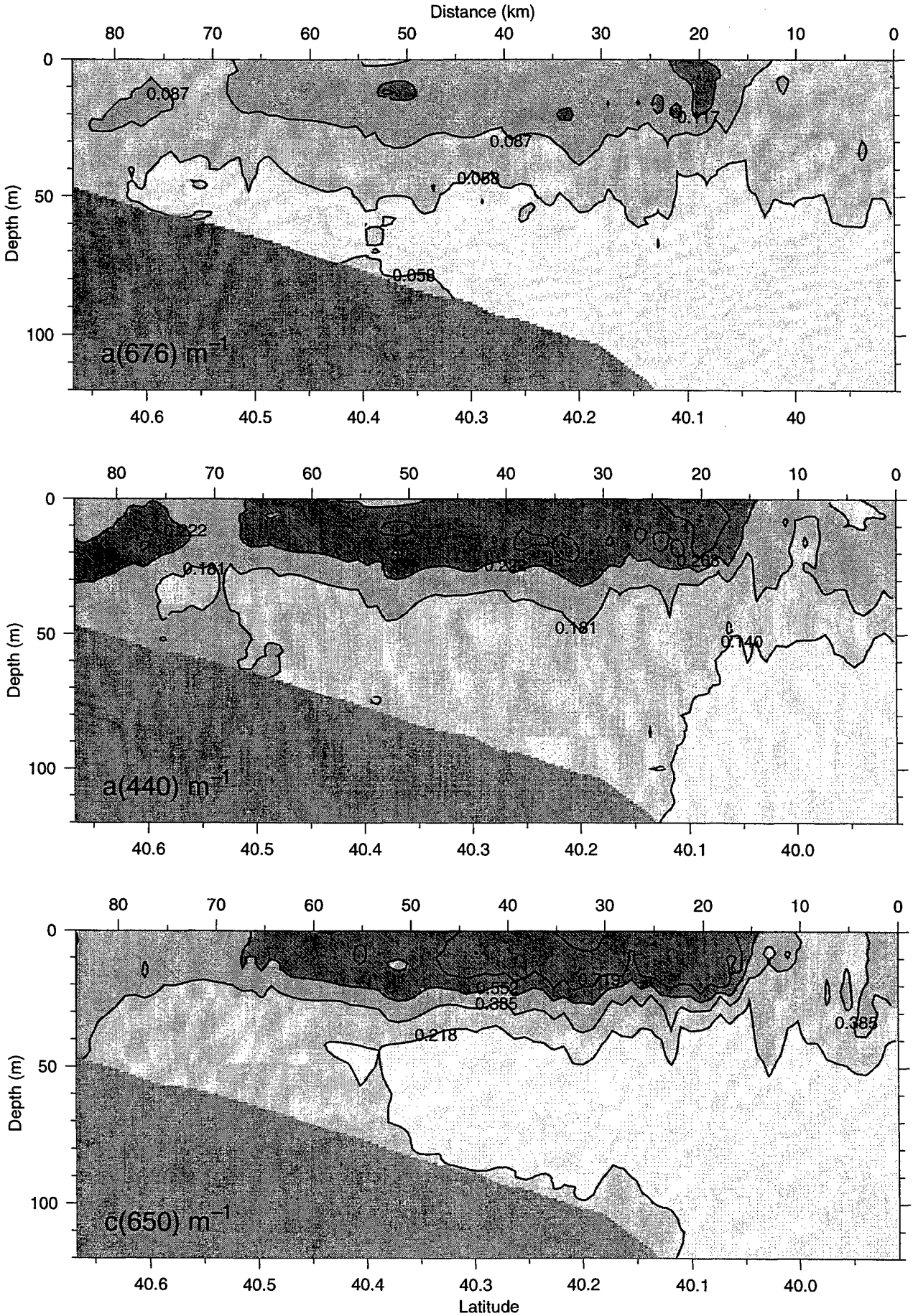
# E9704 Bigbox 1



# E9704 Bigbox 1

## Line E 70.1999°W

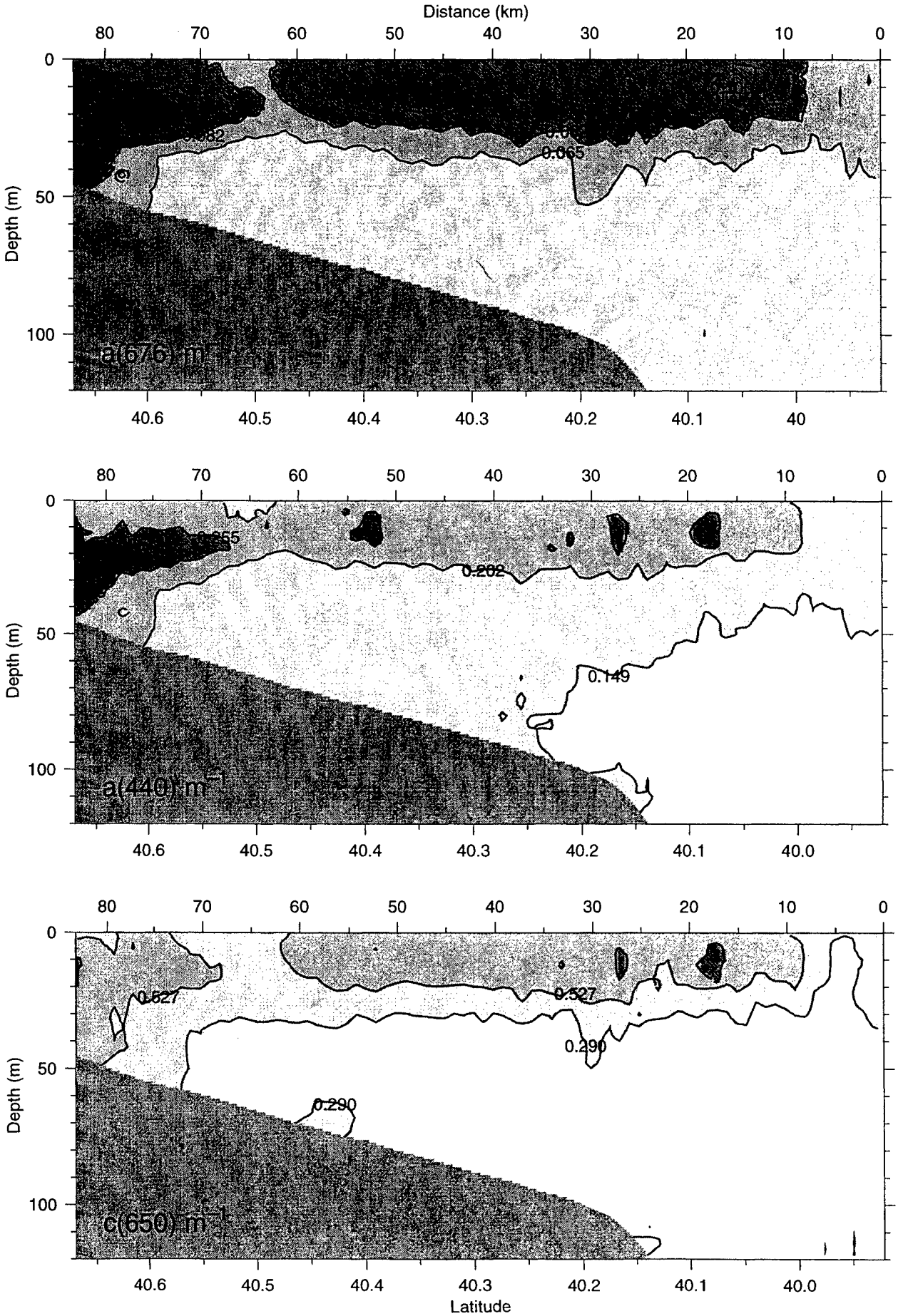
05-May-97 17:07 to 06-May-97 00:32



# E9704 Bigbox 1

## Line F 70.0585°W

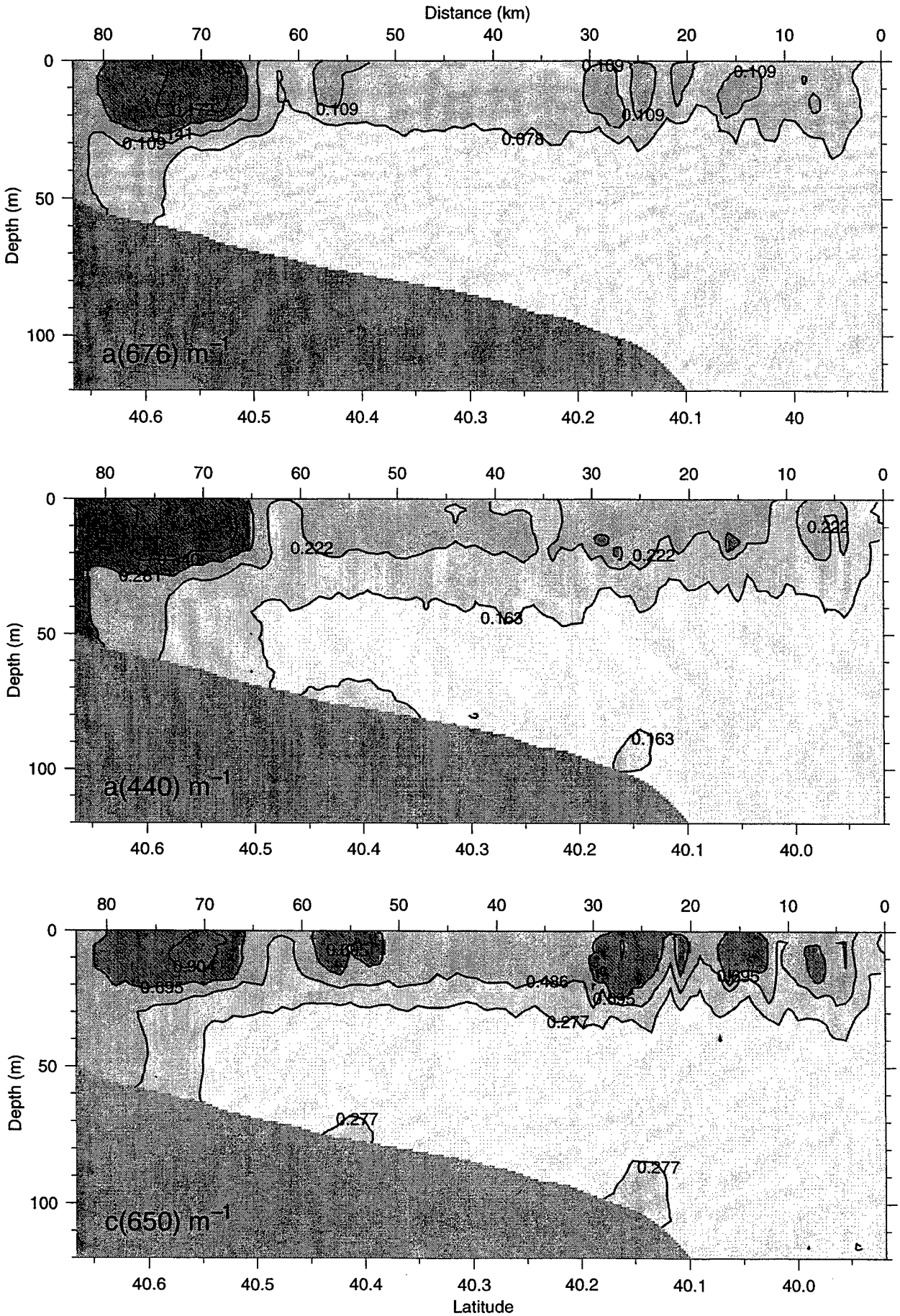
06-May-97 03:41 to 06-May-97 10:15



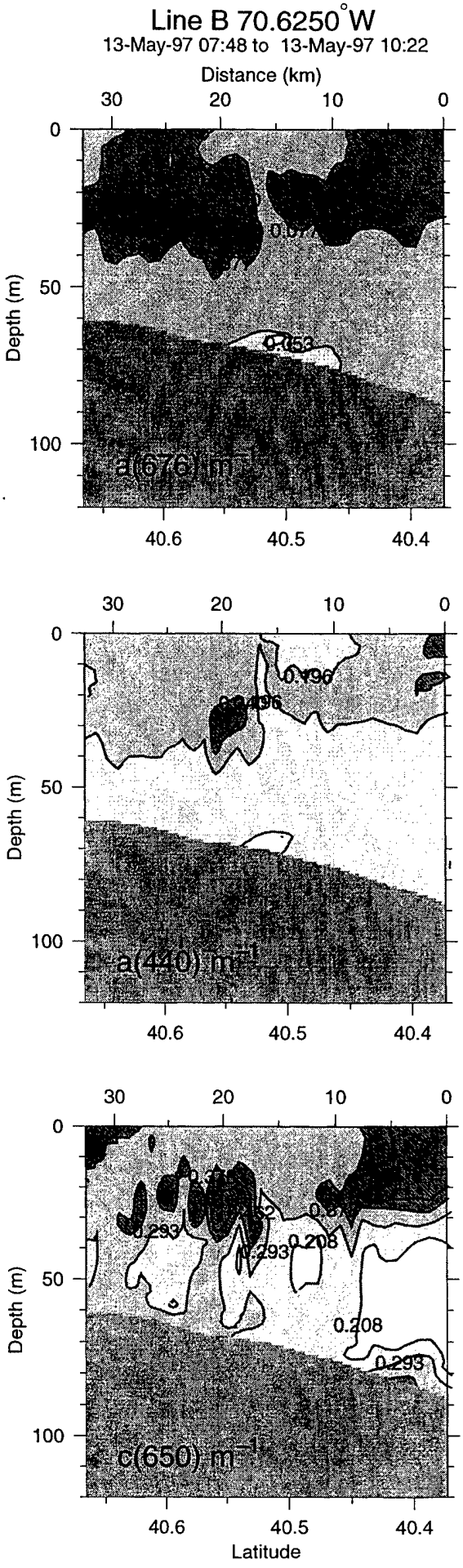
# E9704 Bigbox 1

## Line G 69.9166°W

06-May-97 11:11 to 06-May-97 17:32



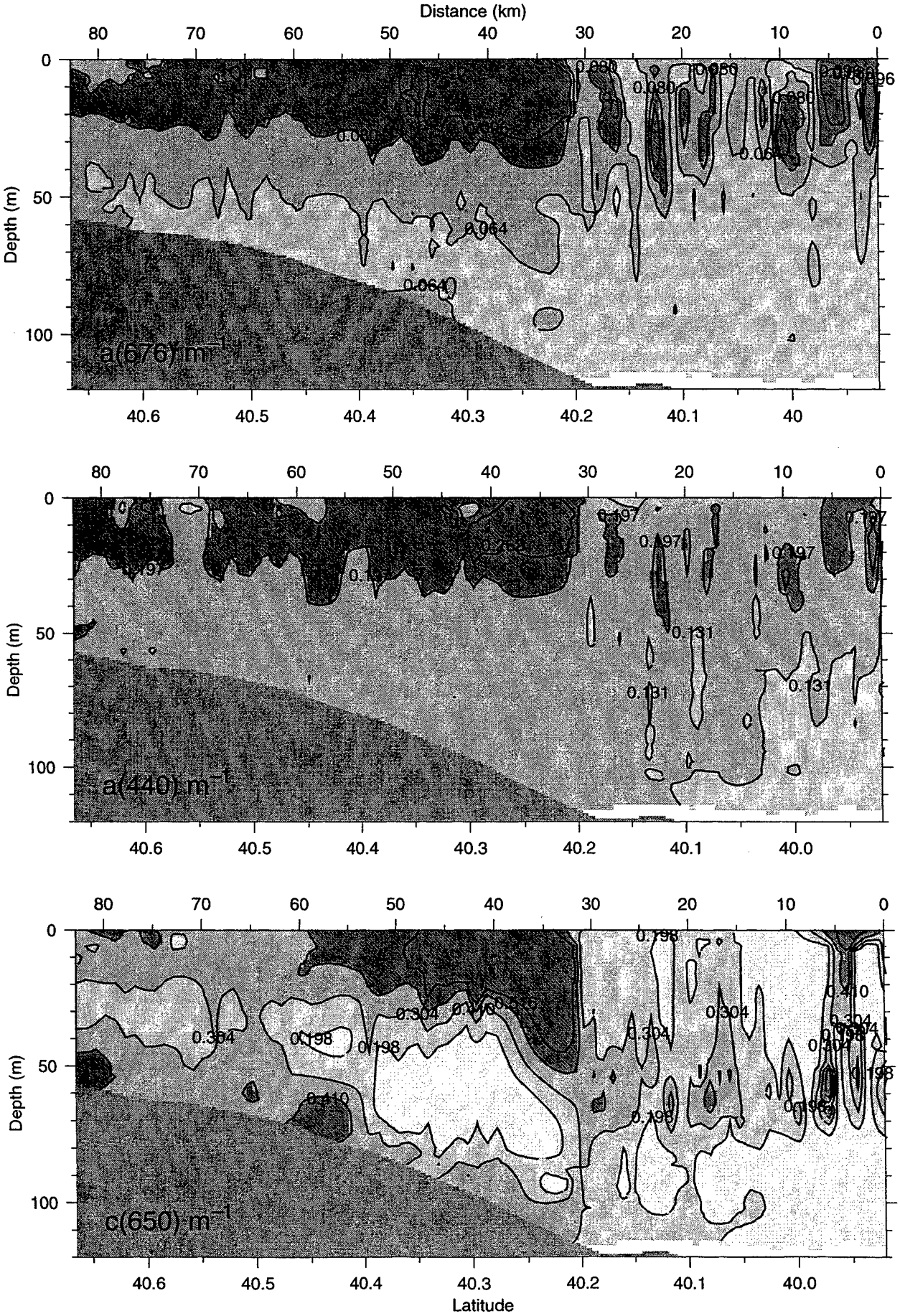
# E9704 Bigbox 2



# E9704 Bigbox 2

## Line C 70.4833°W

12-May-97 16:00 to 12-May-97 22:35



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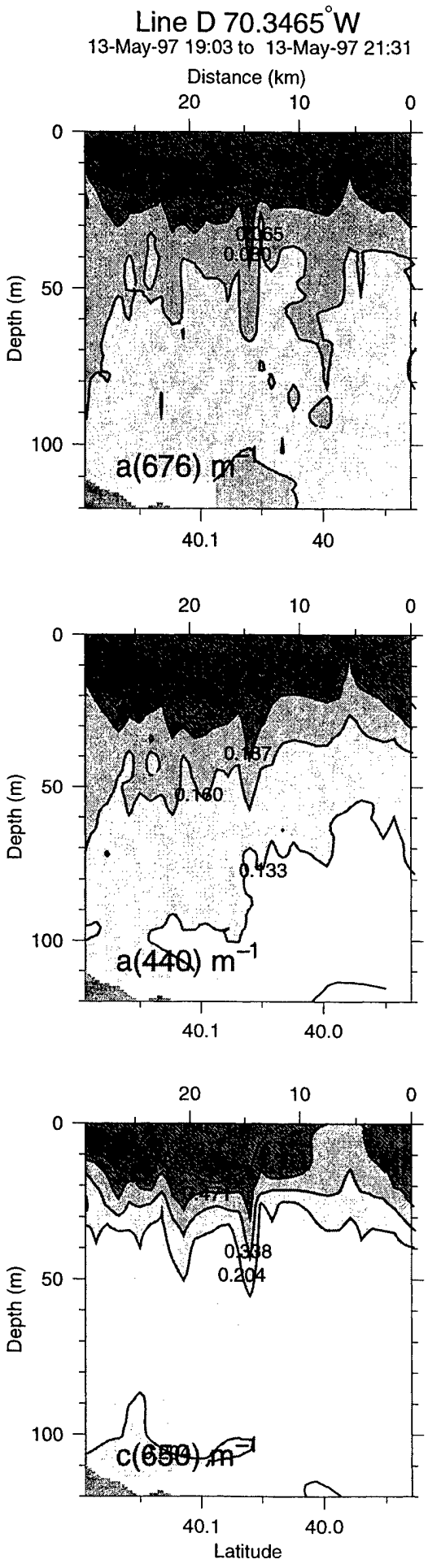
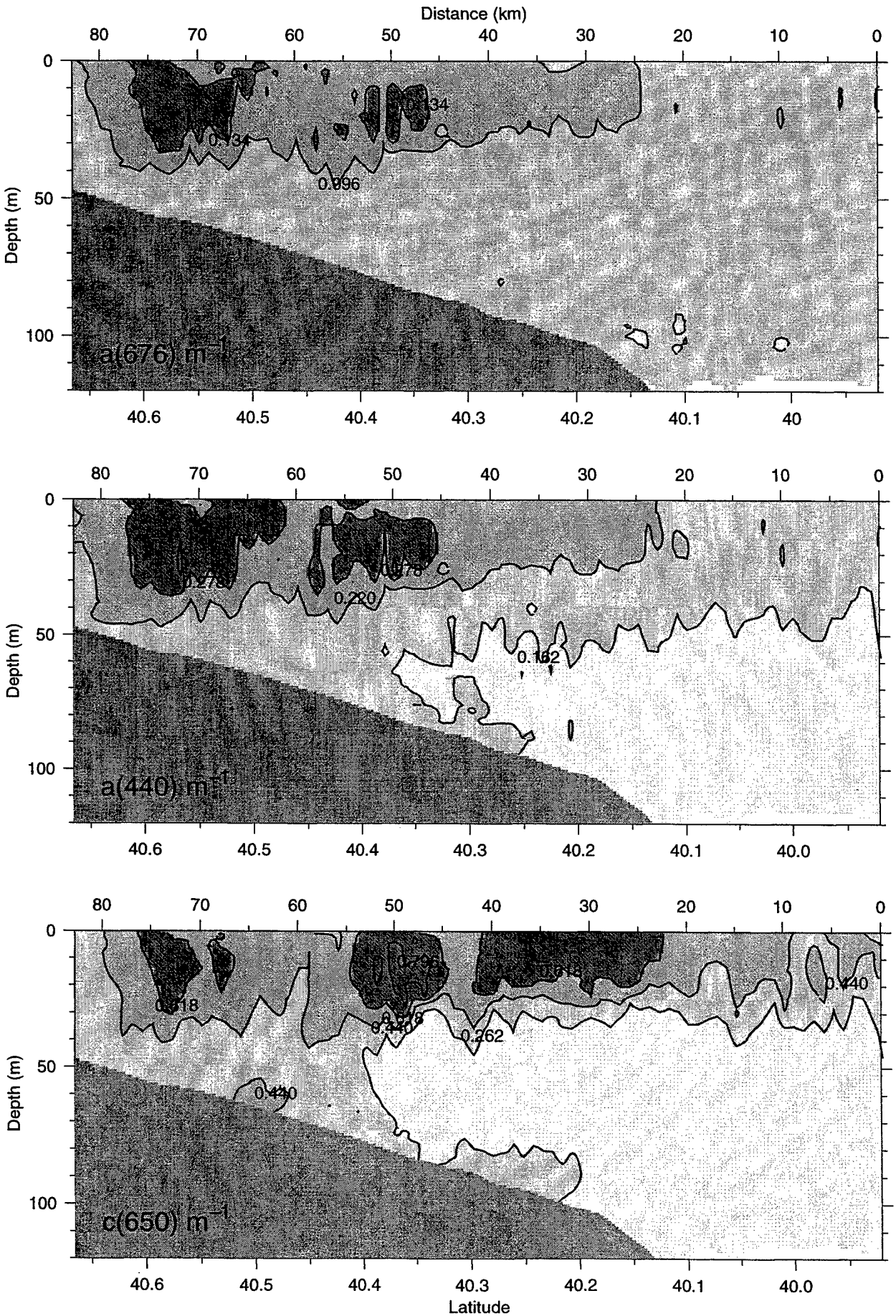


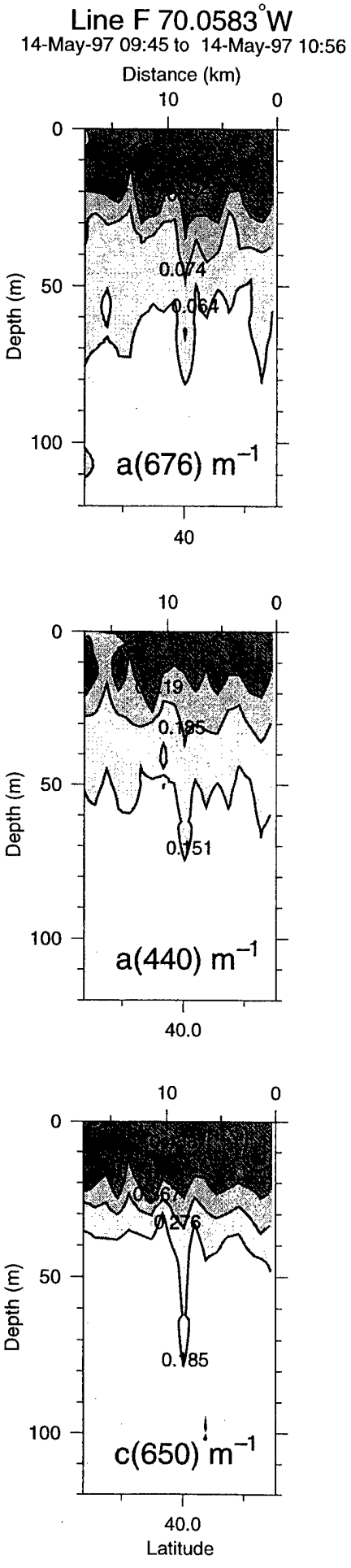
# E9704 Bigbox 2

## Line E 70.2000°W

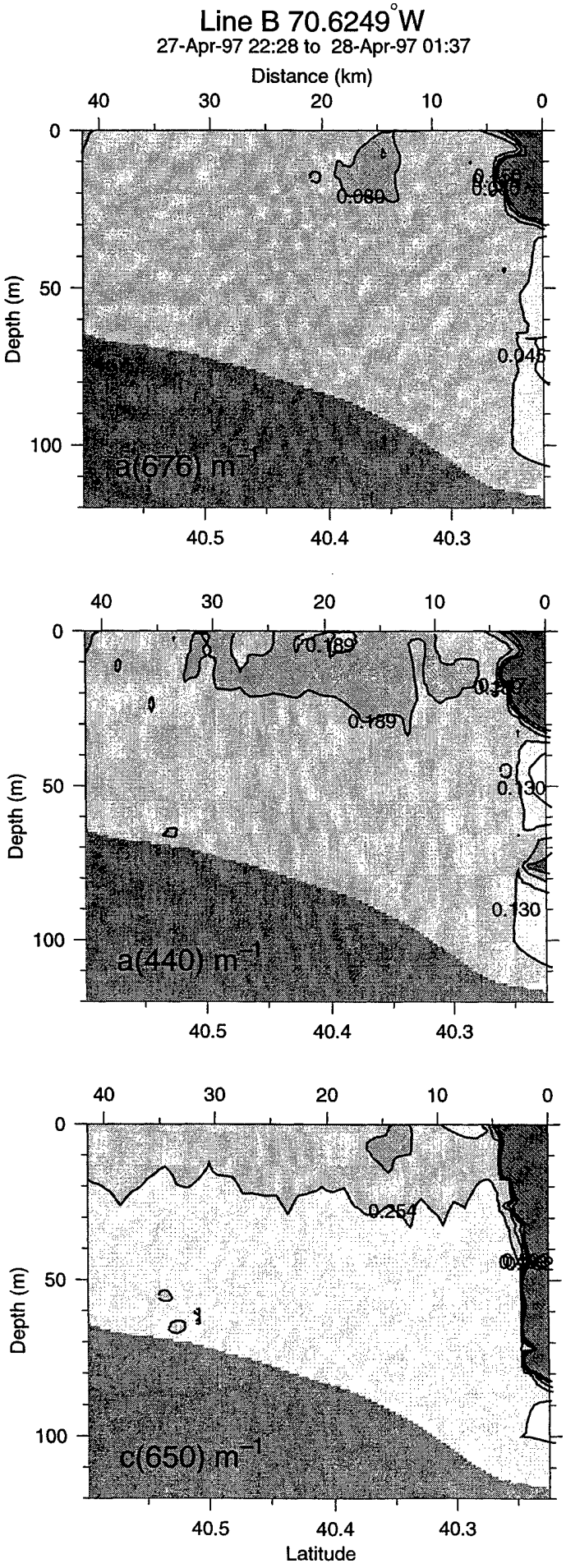
14-May-97 02:31 to 14-May-97 08:50



# E9704 Bigbox 2



# E9704 Smallbox 2



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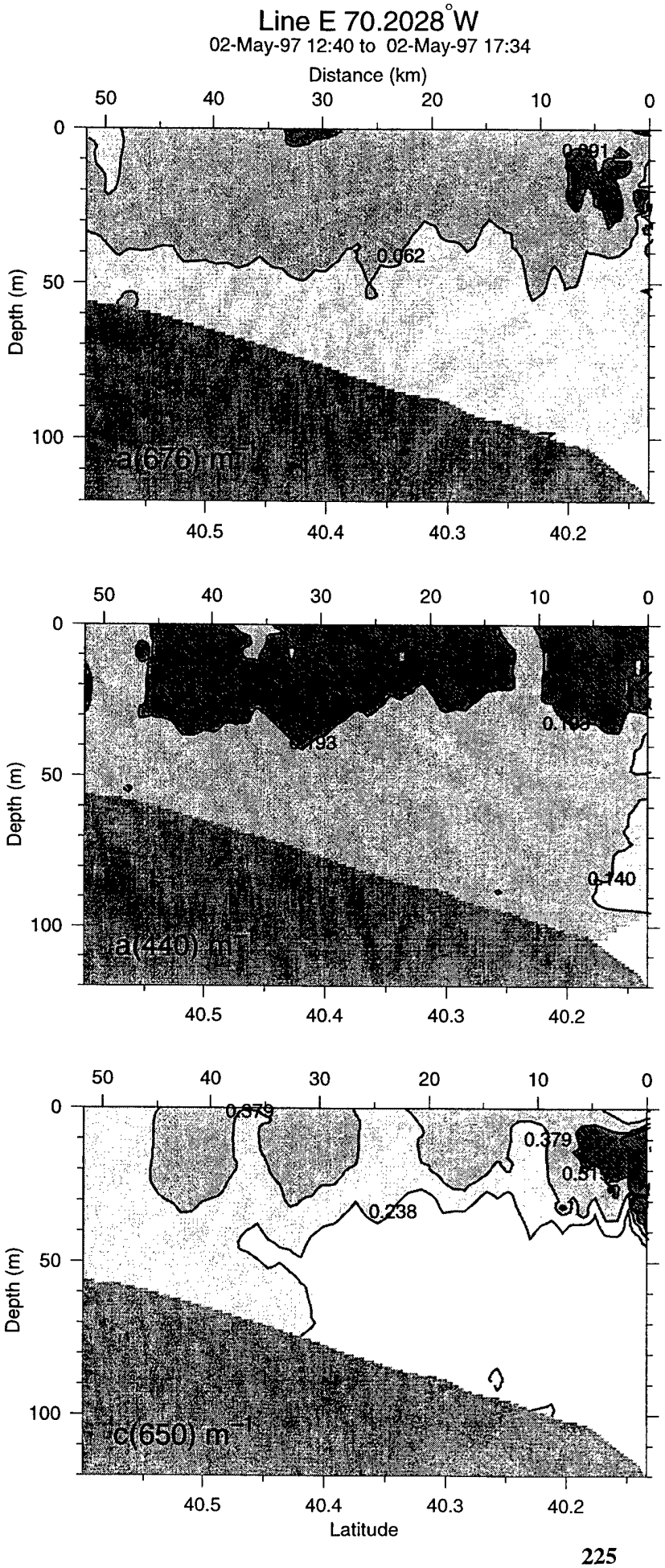
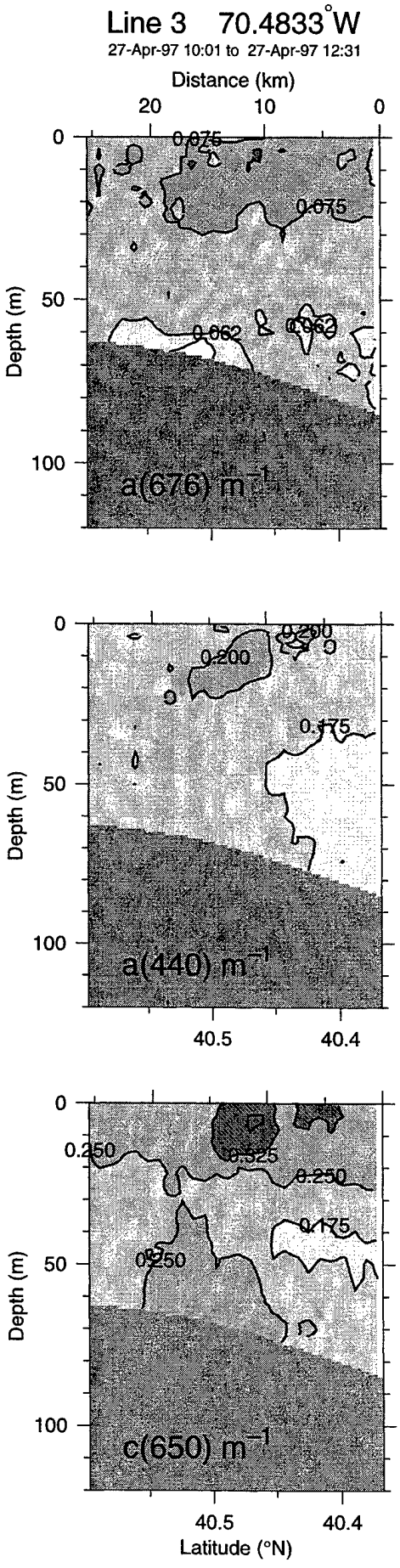
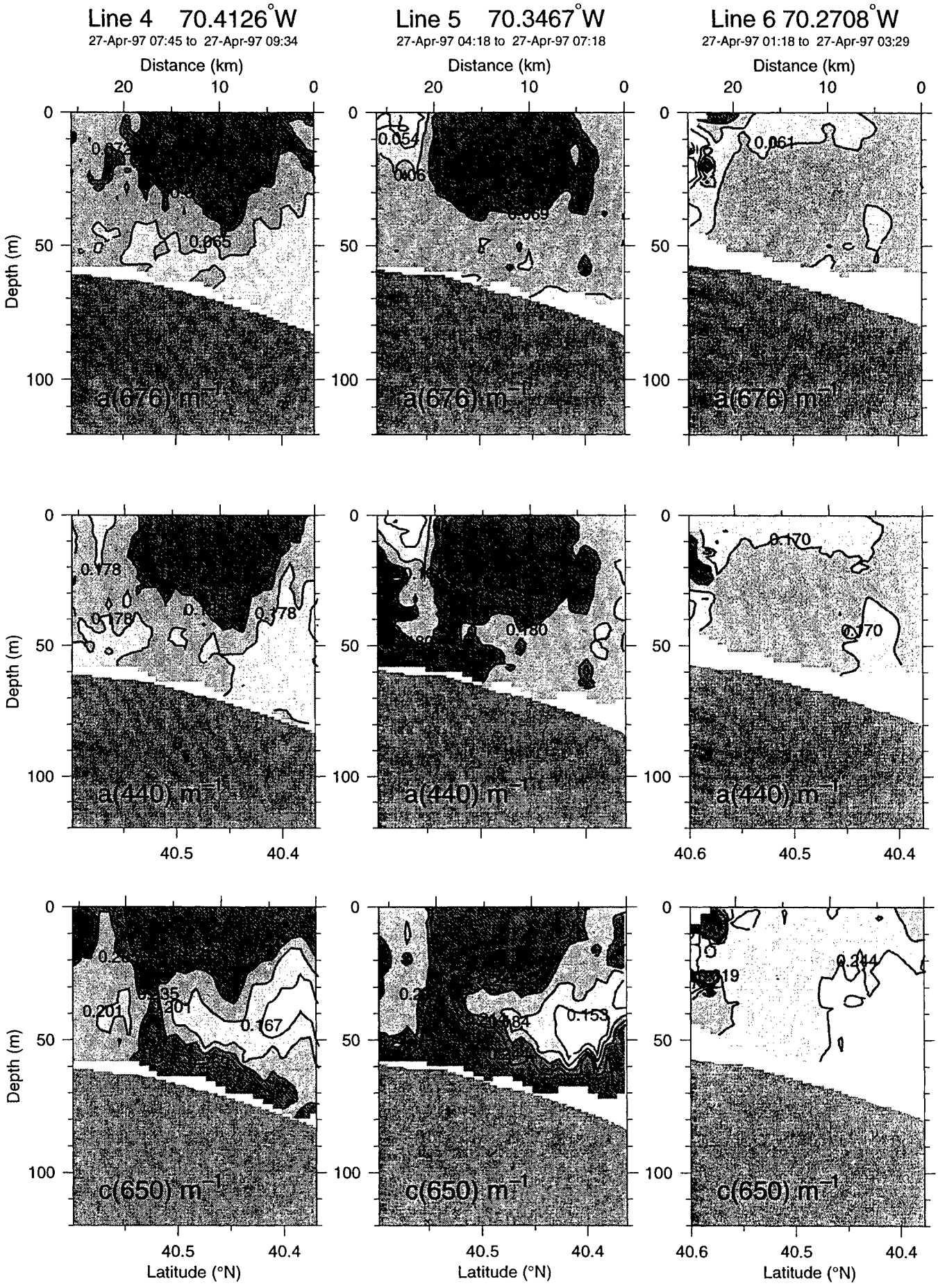


# E9704 Smallbox Sections

# E9704 Smallbox 1



# E9704 Smallbox 1



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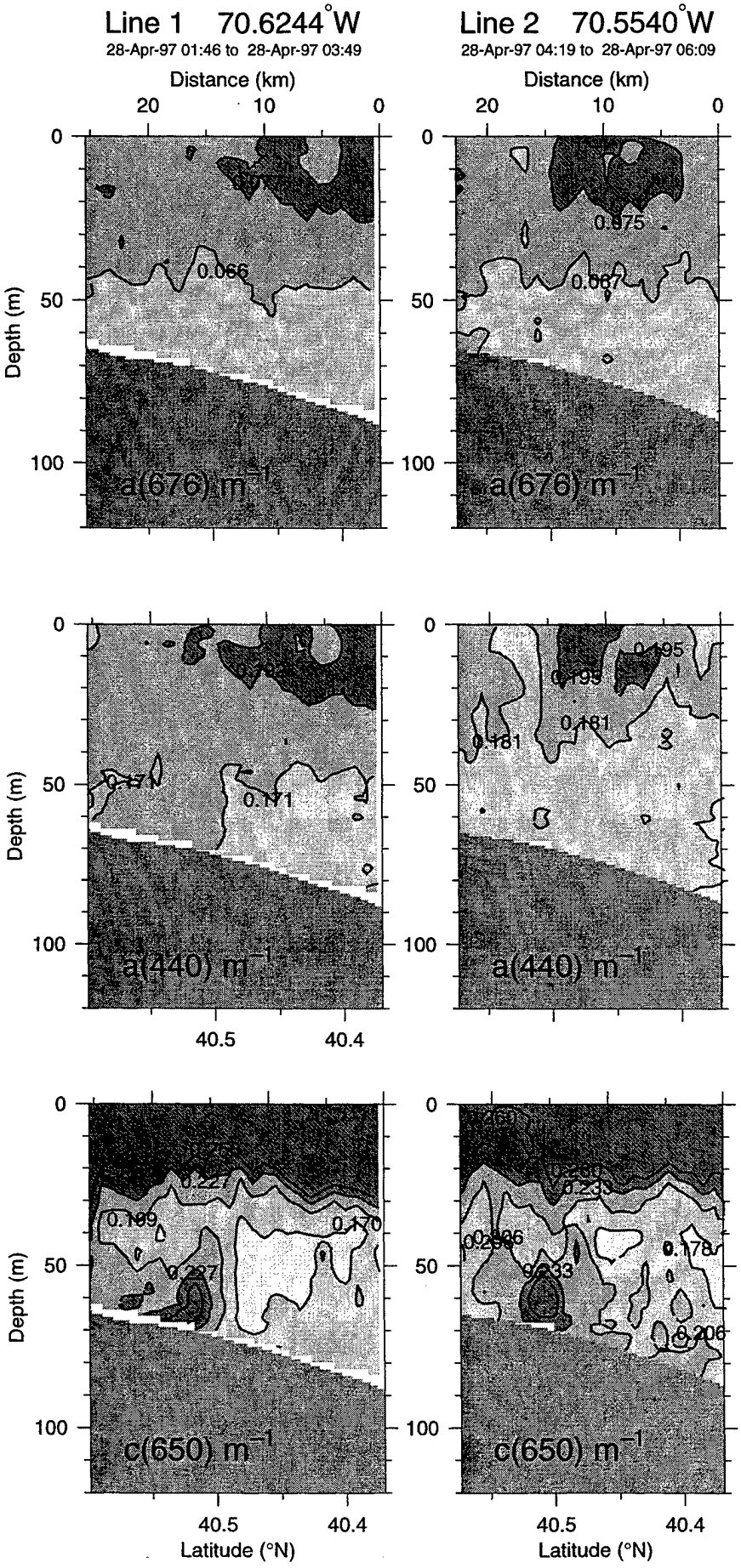

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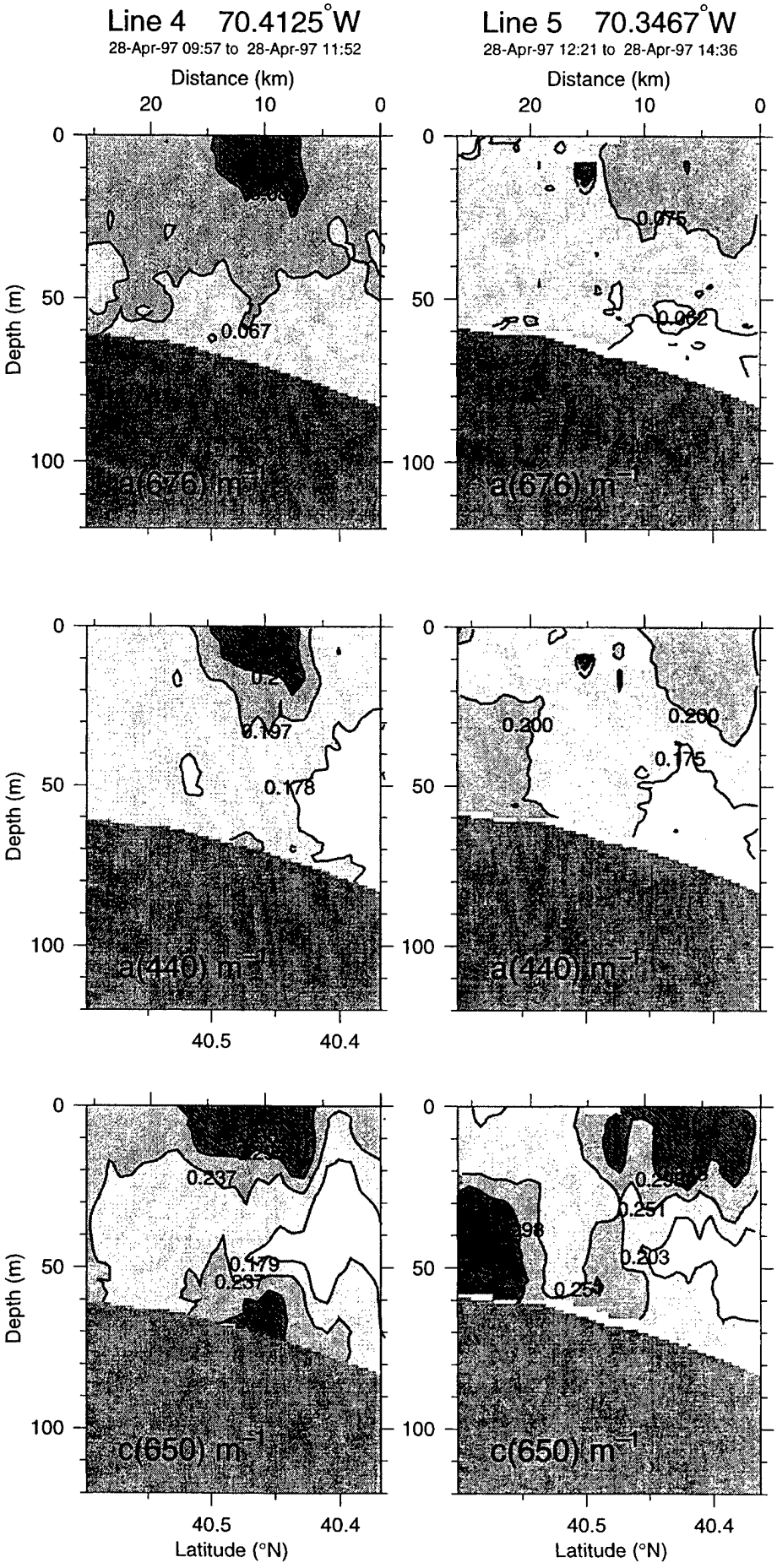

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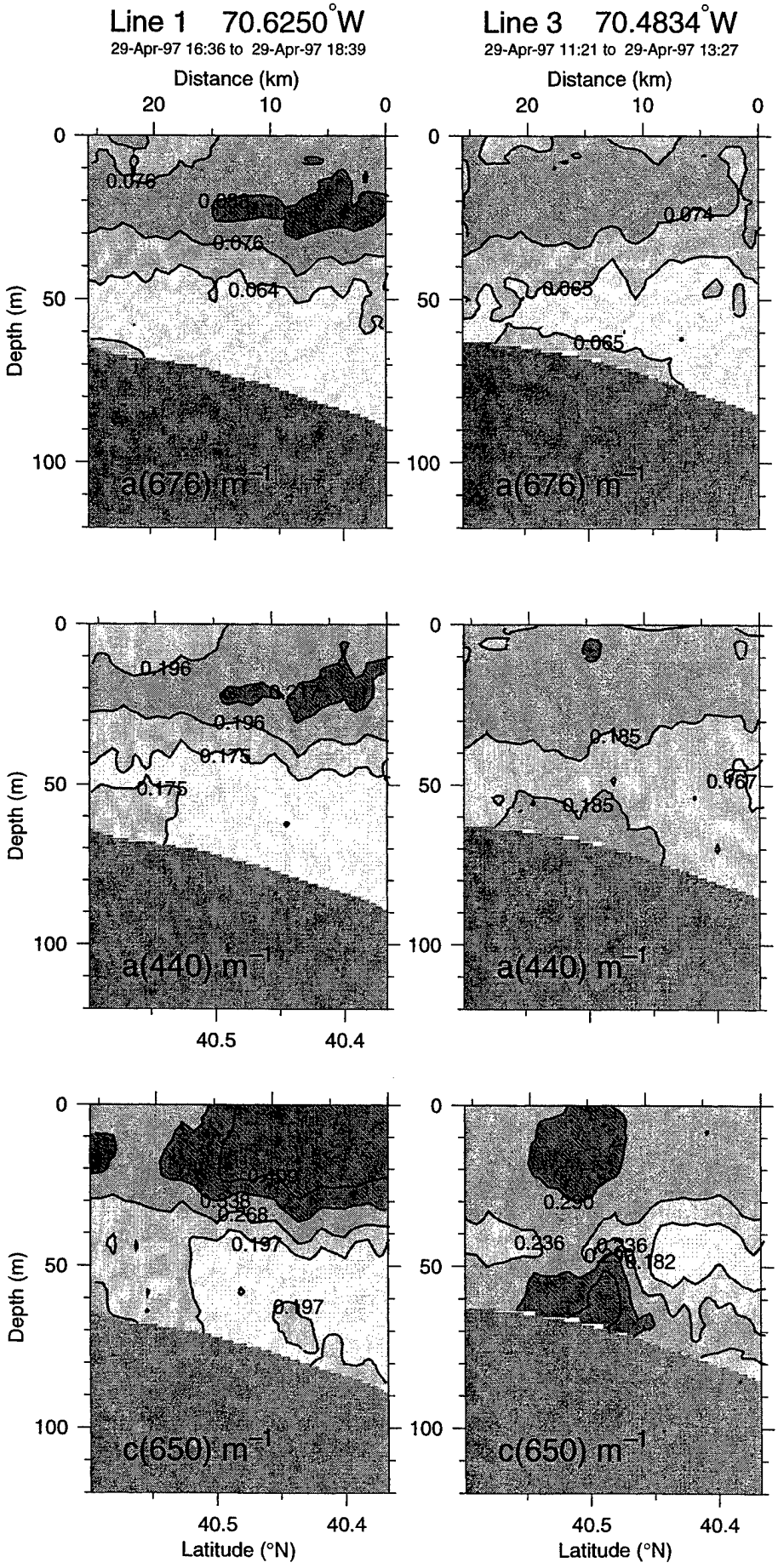

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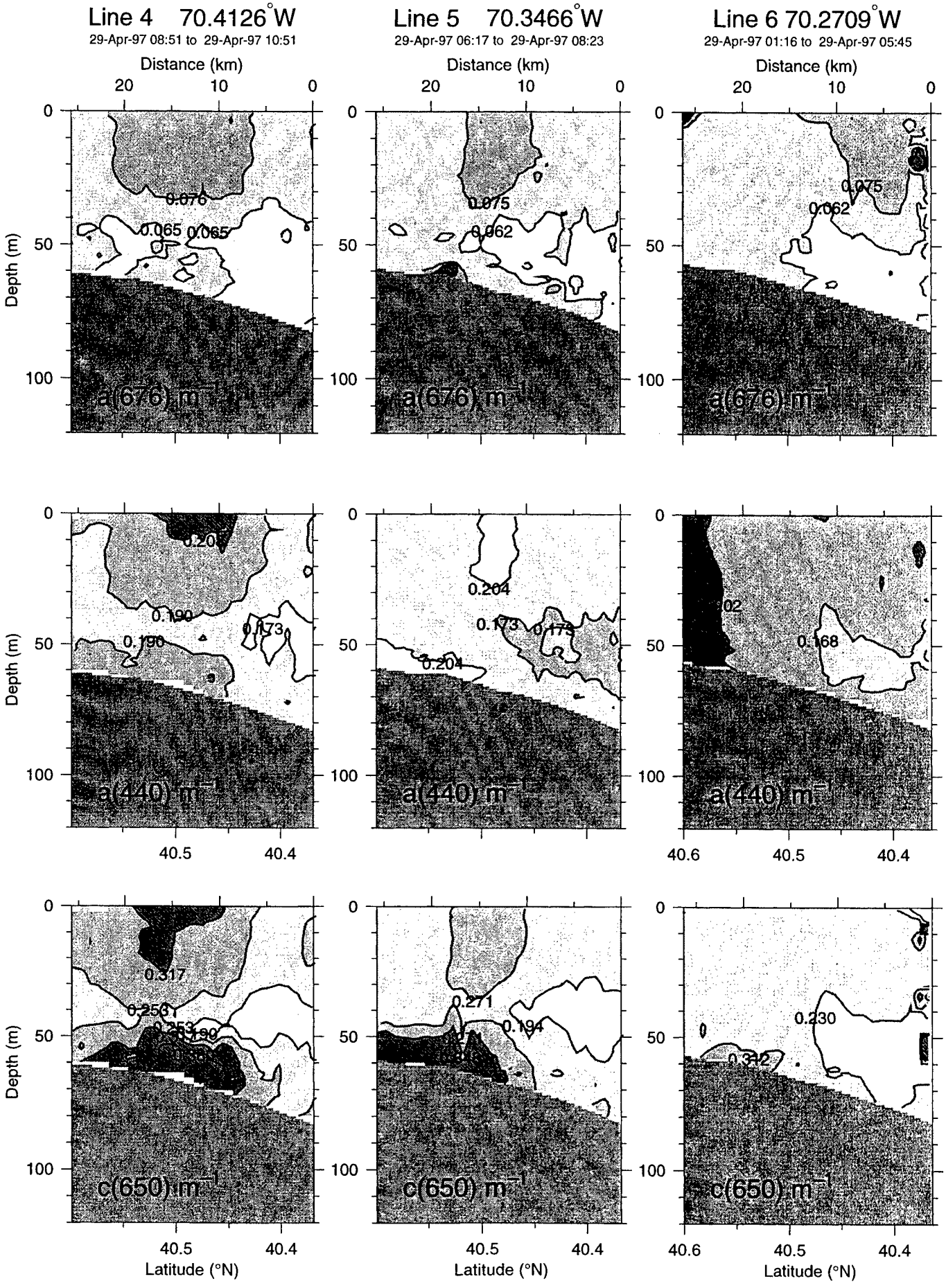

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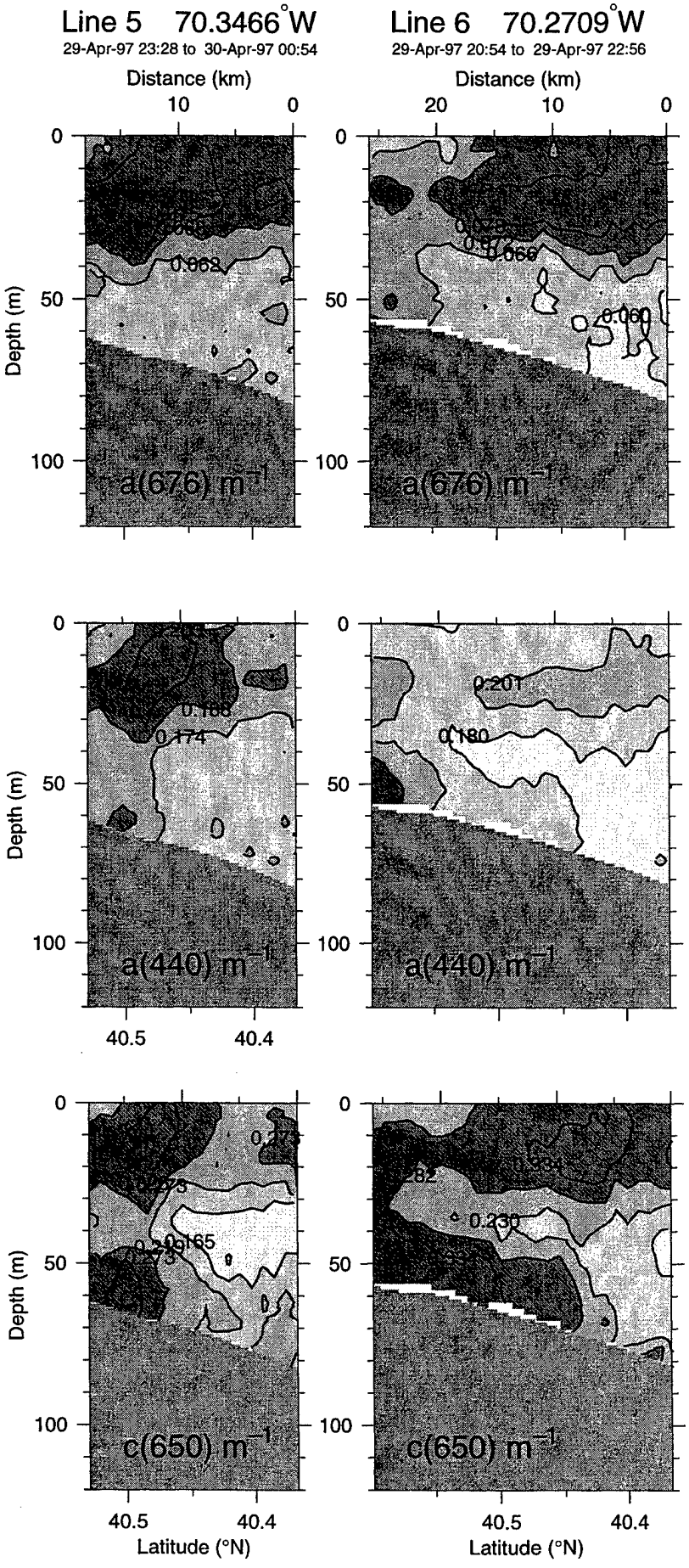

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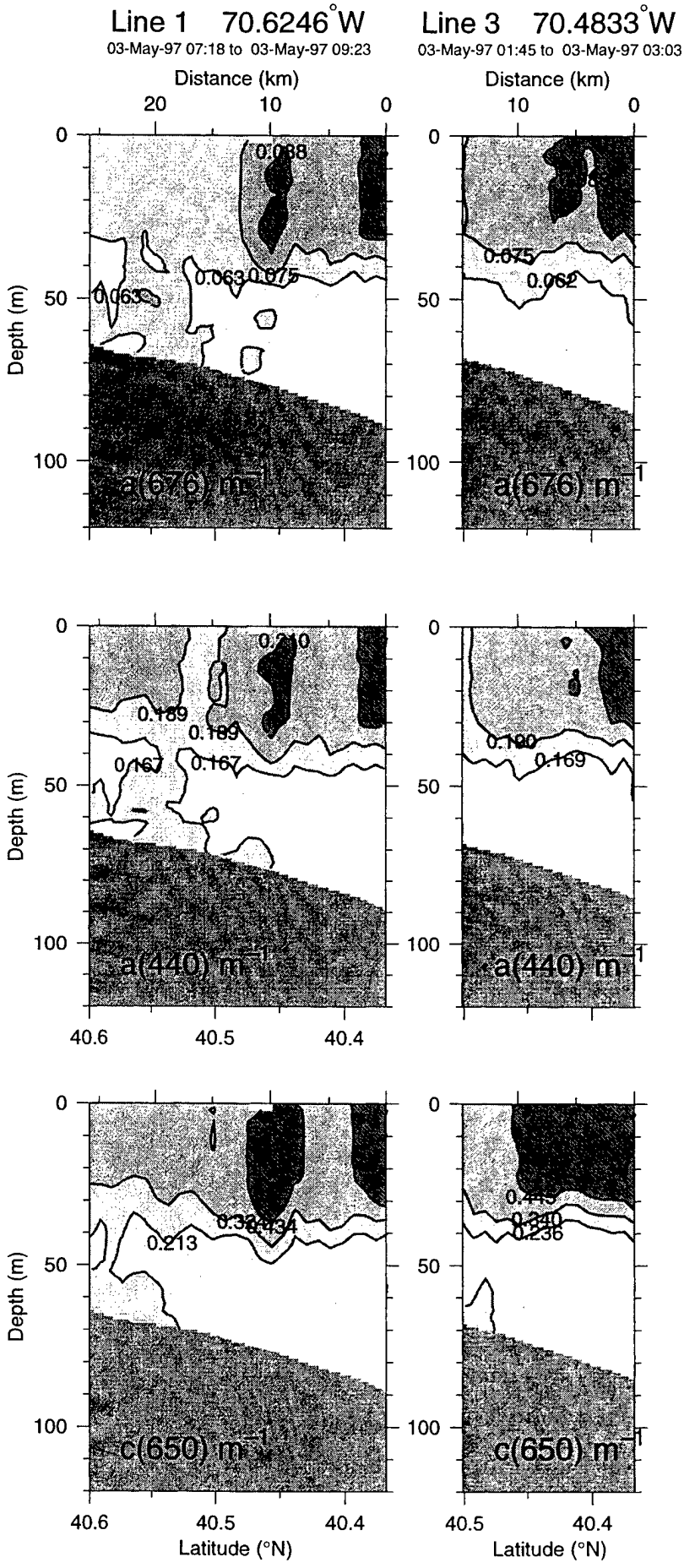

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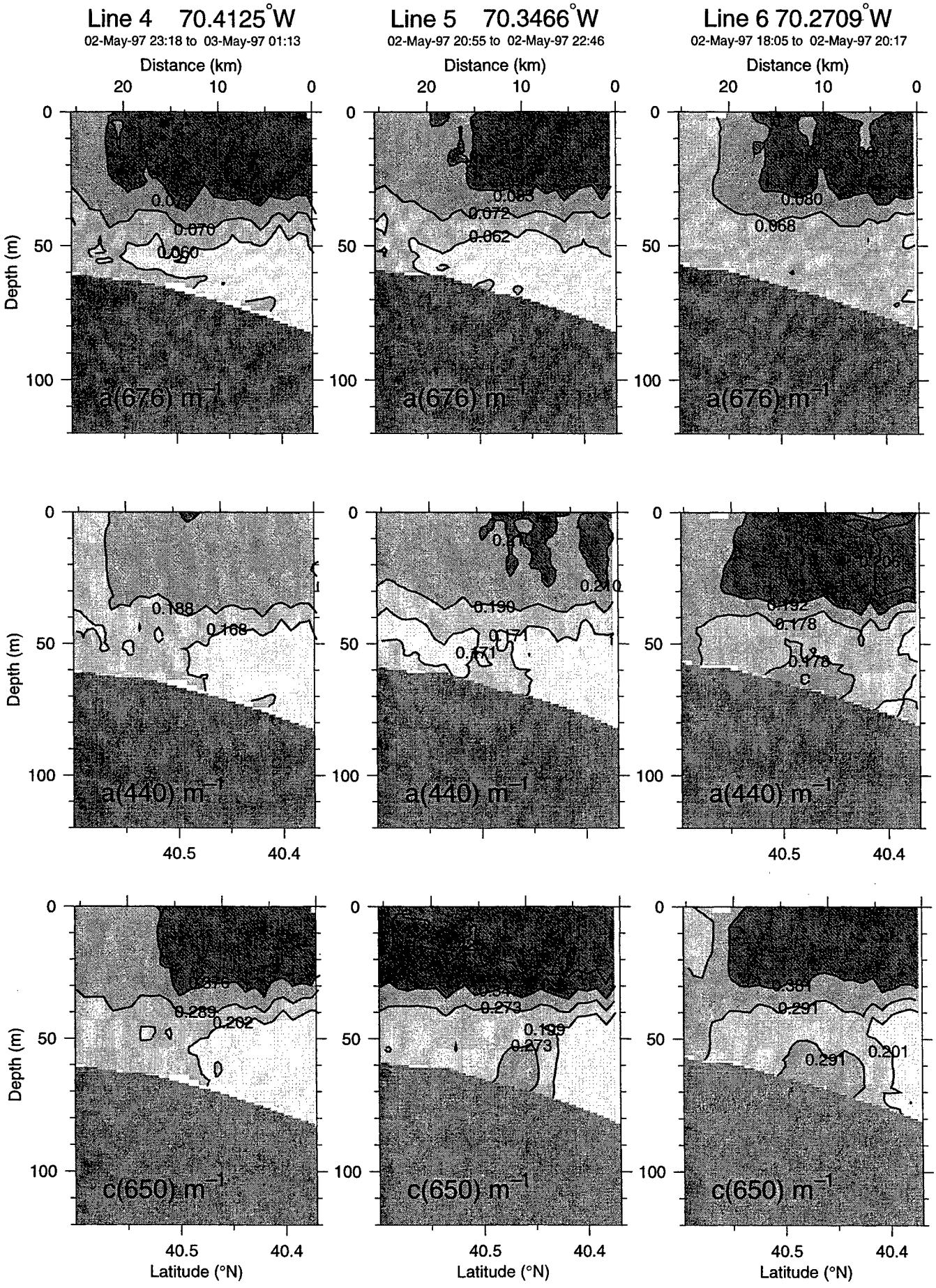
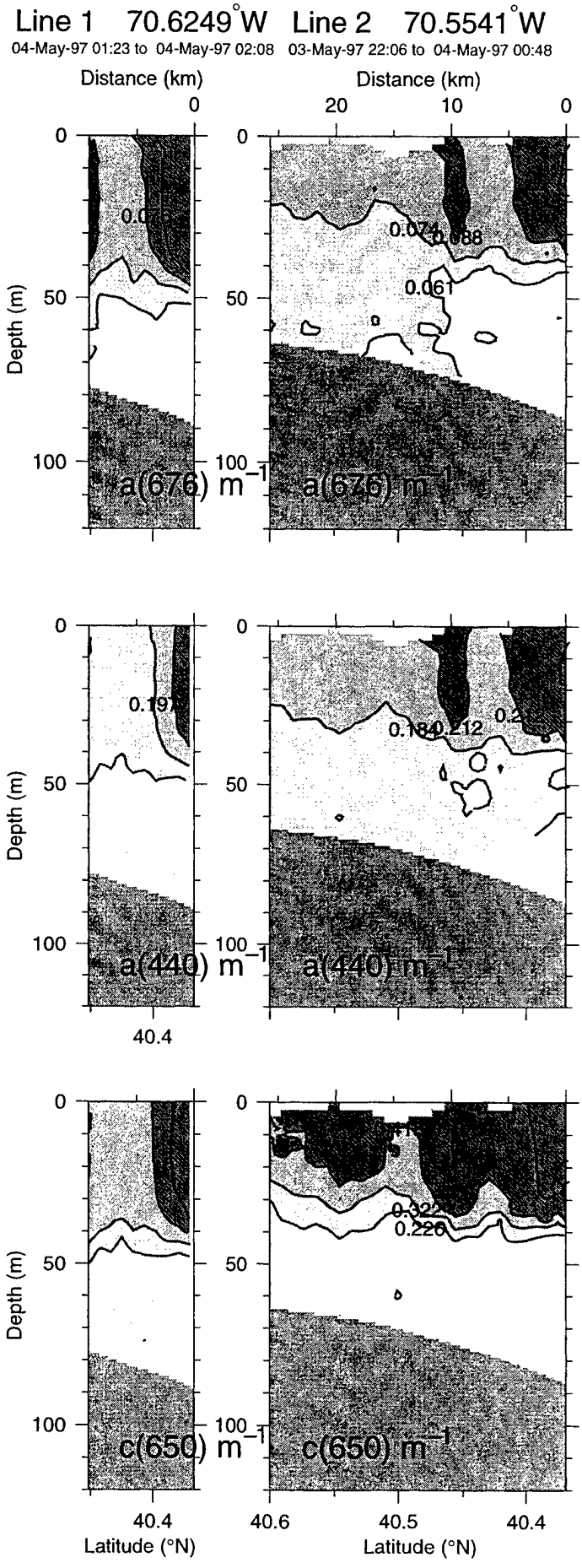


# E9704 Smallbox 6



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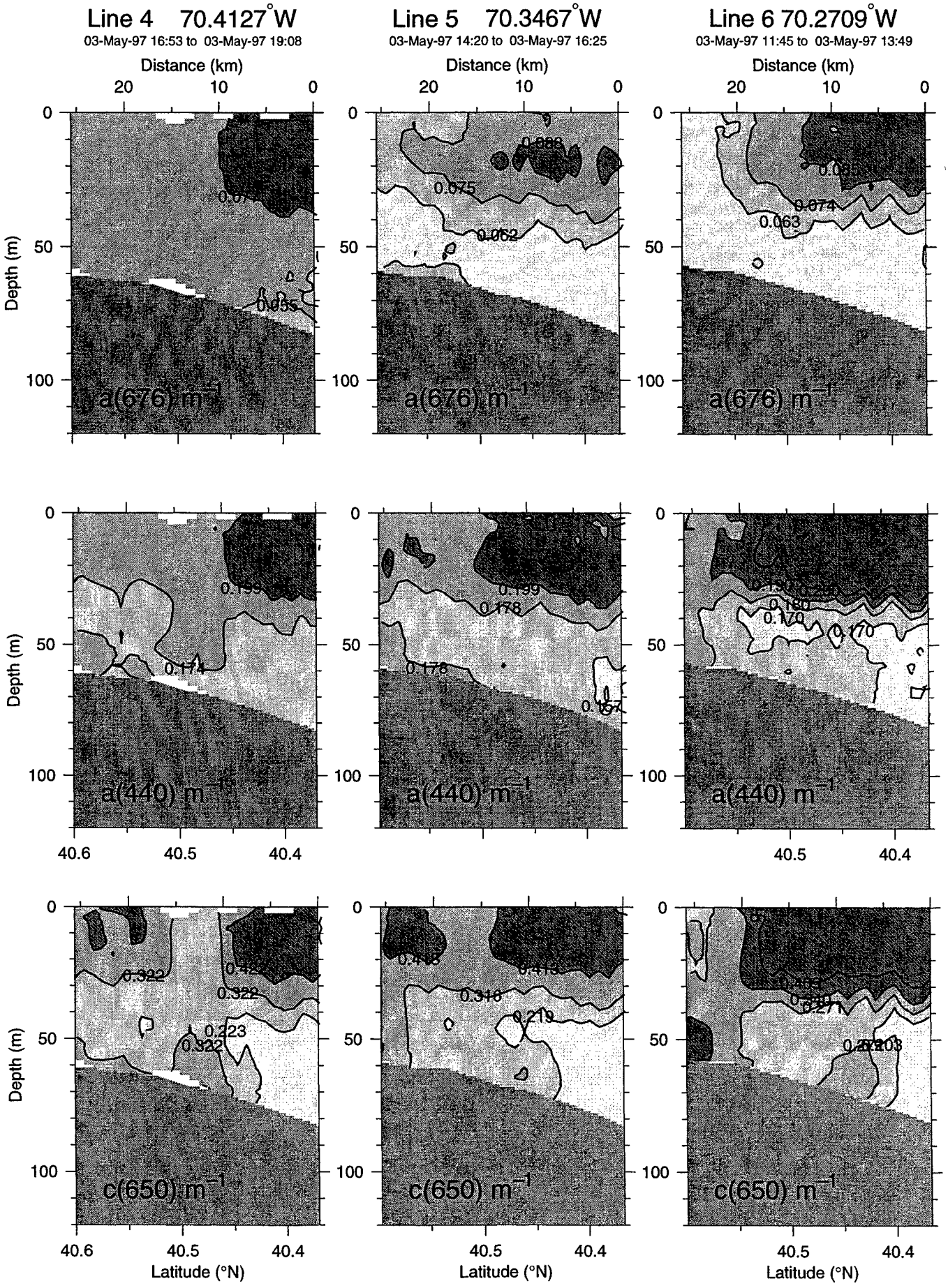

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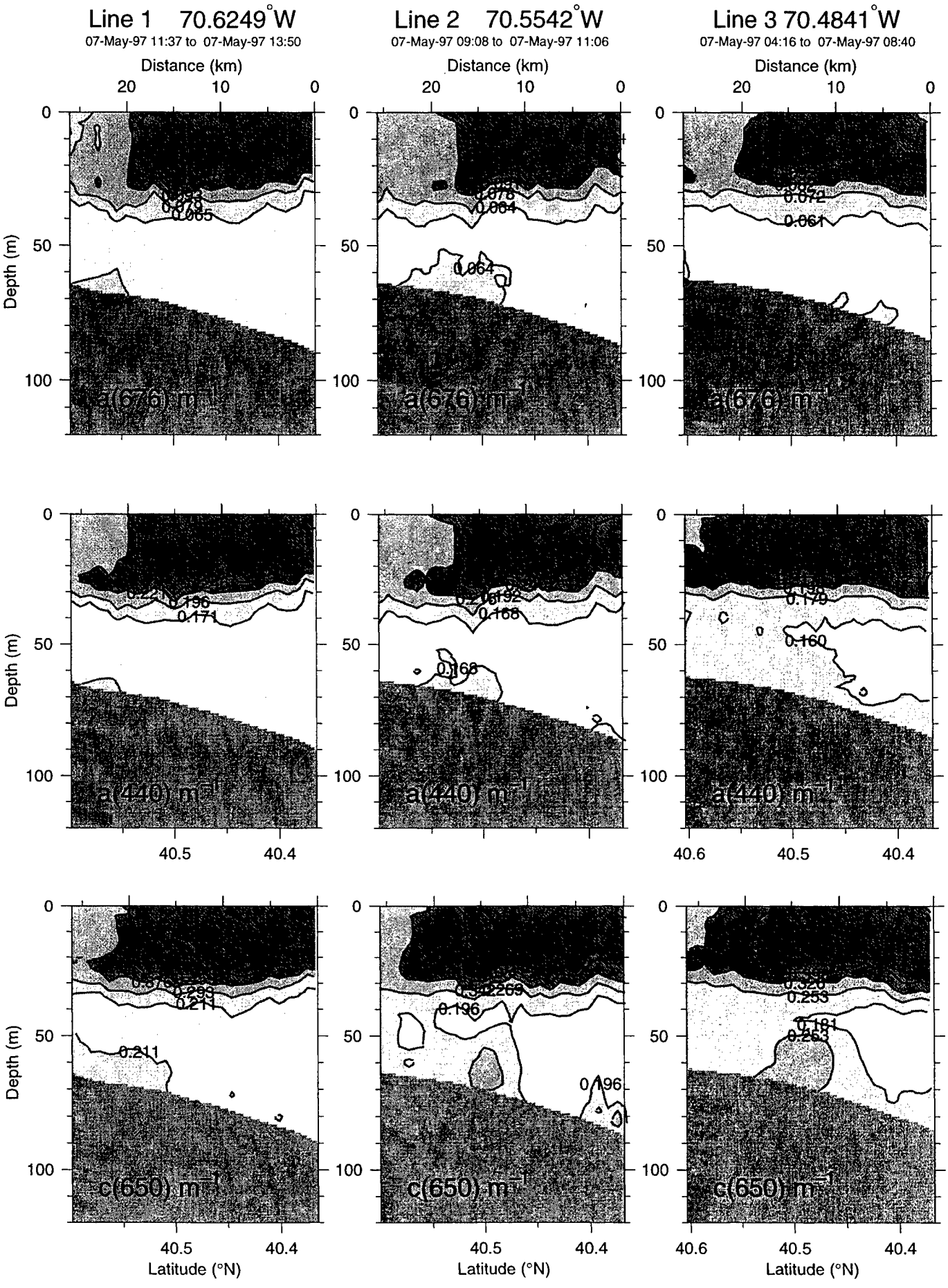

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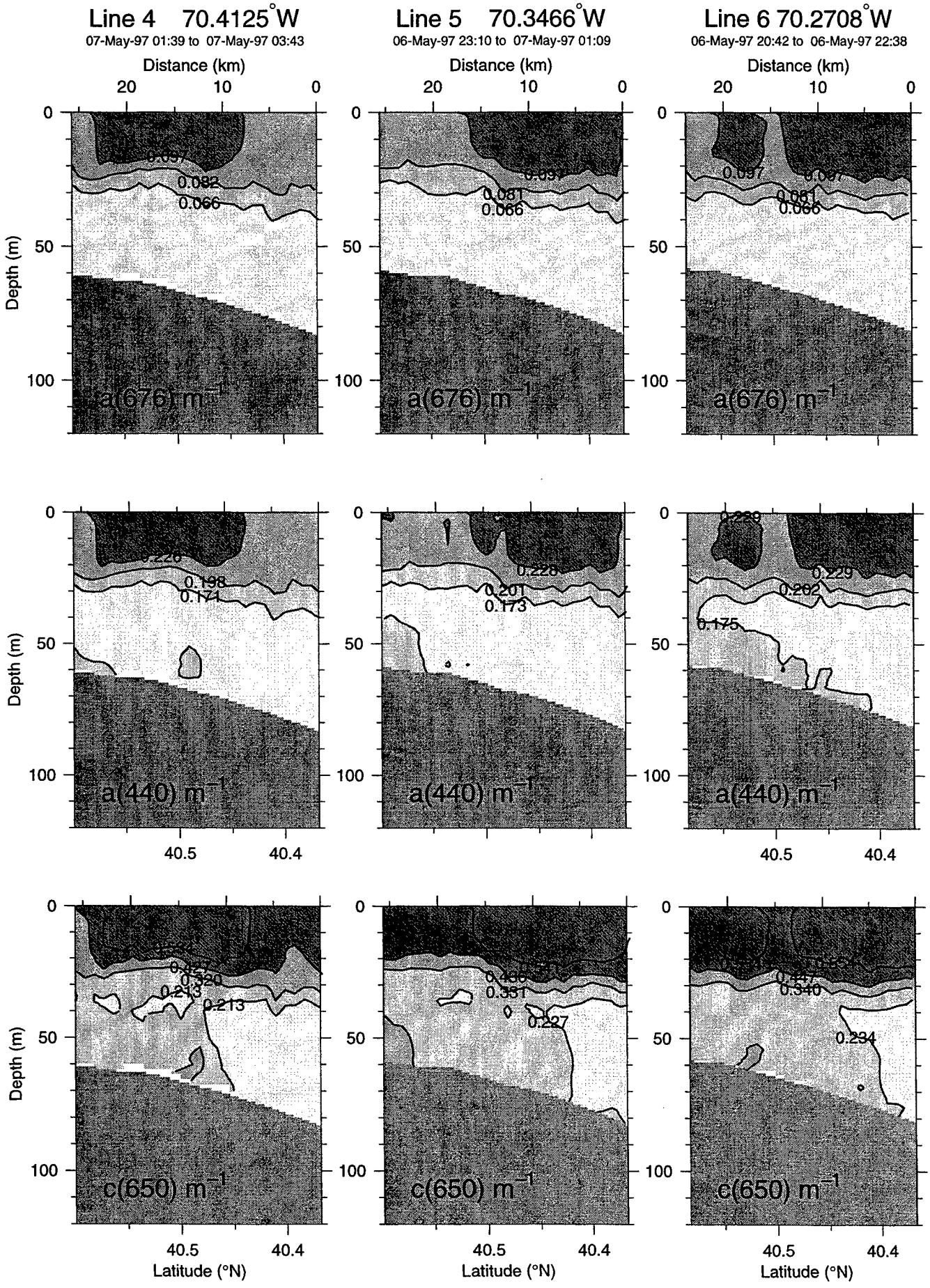
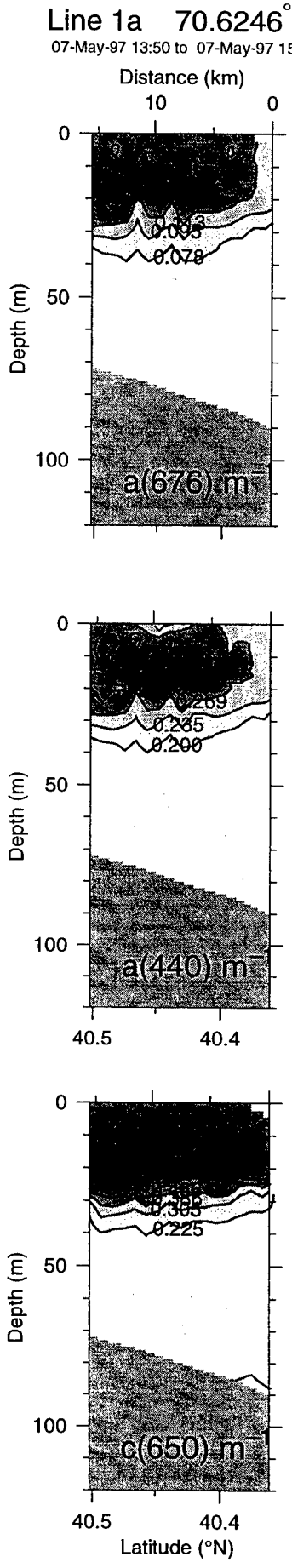
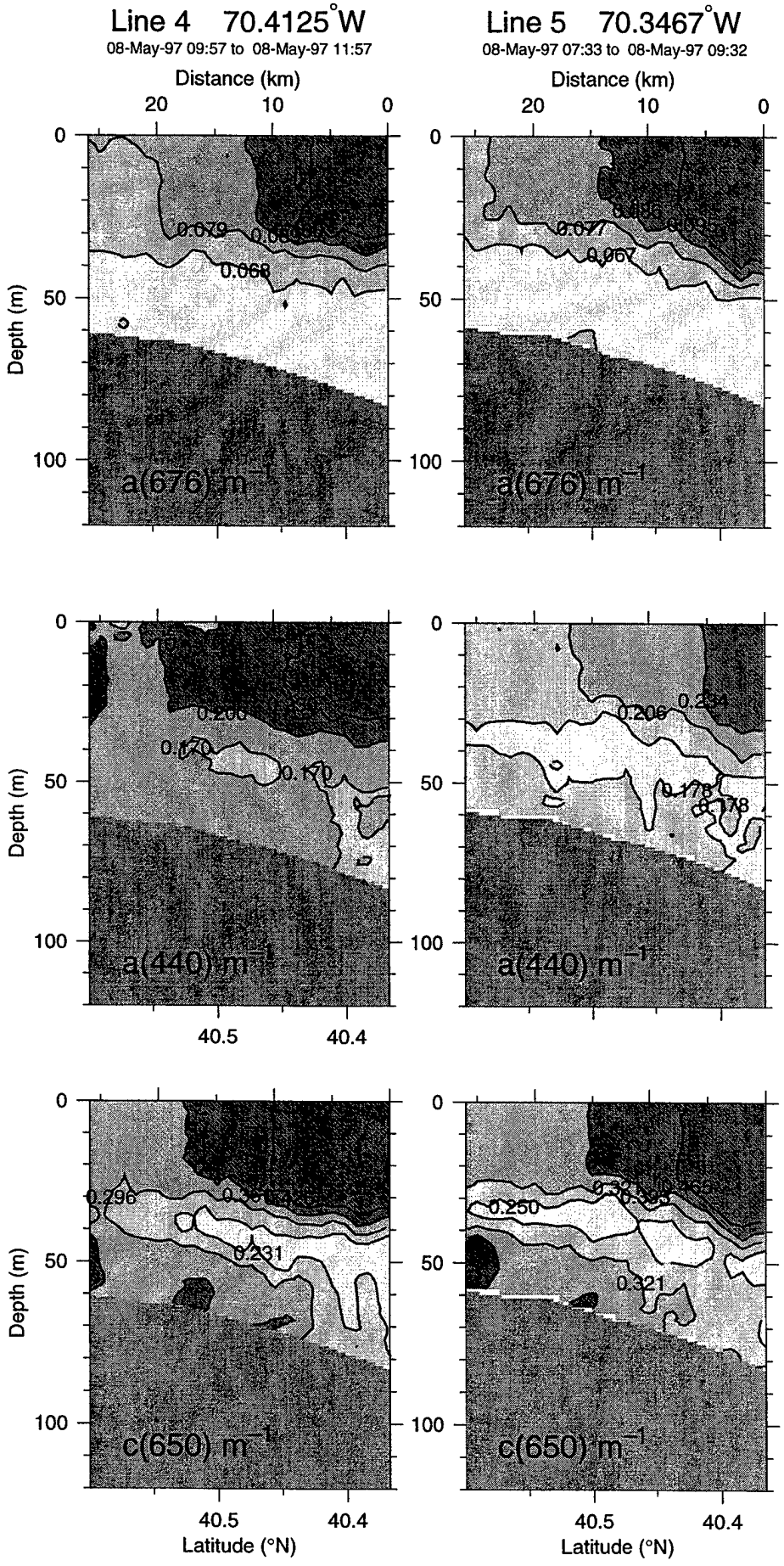


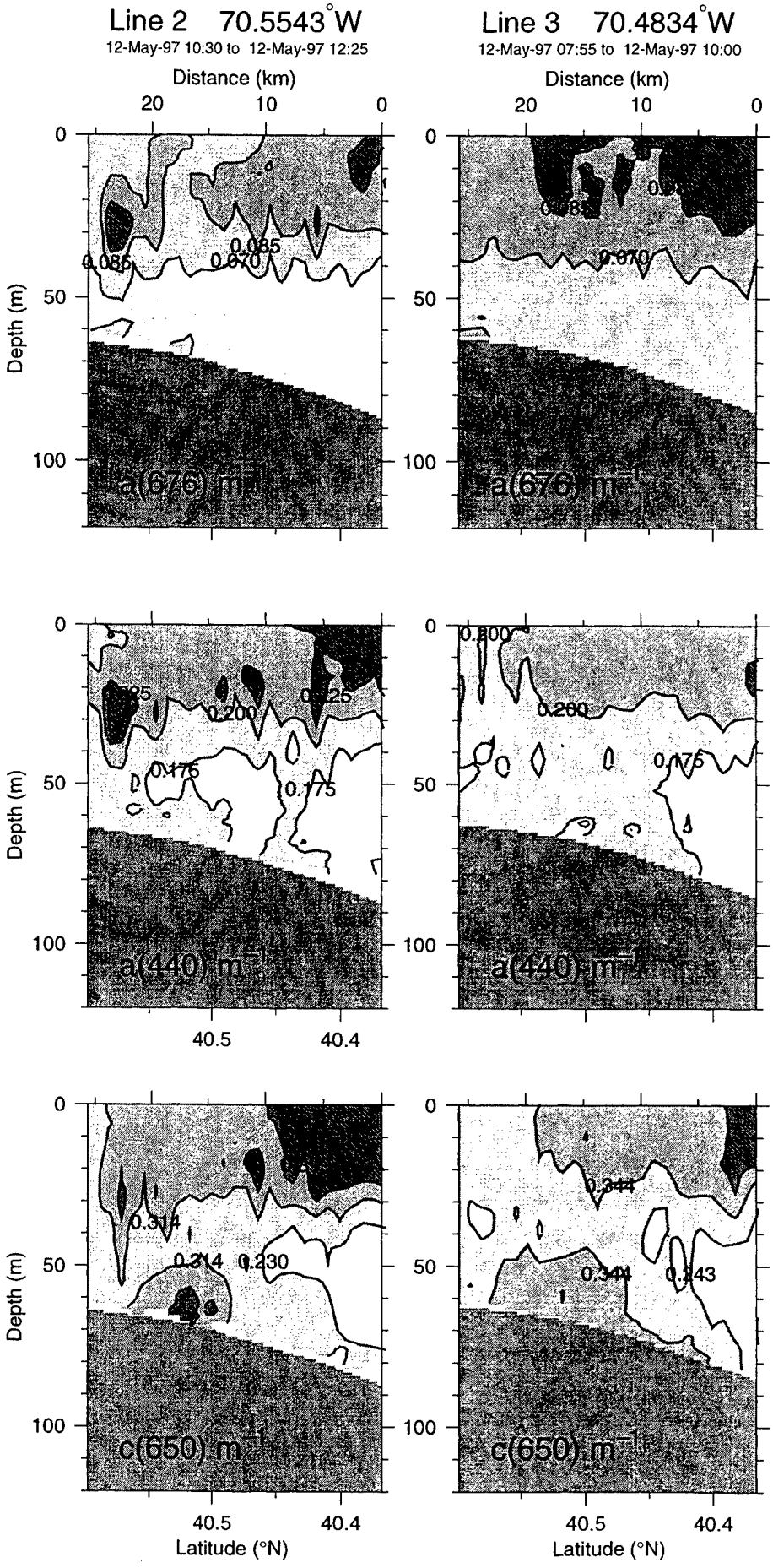
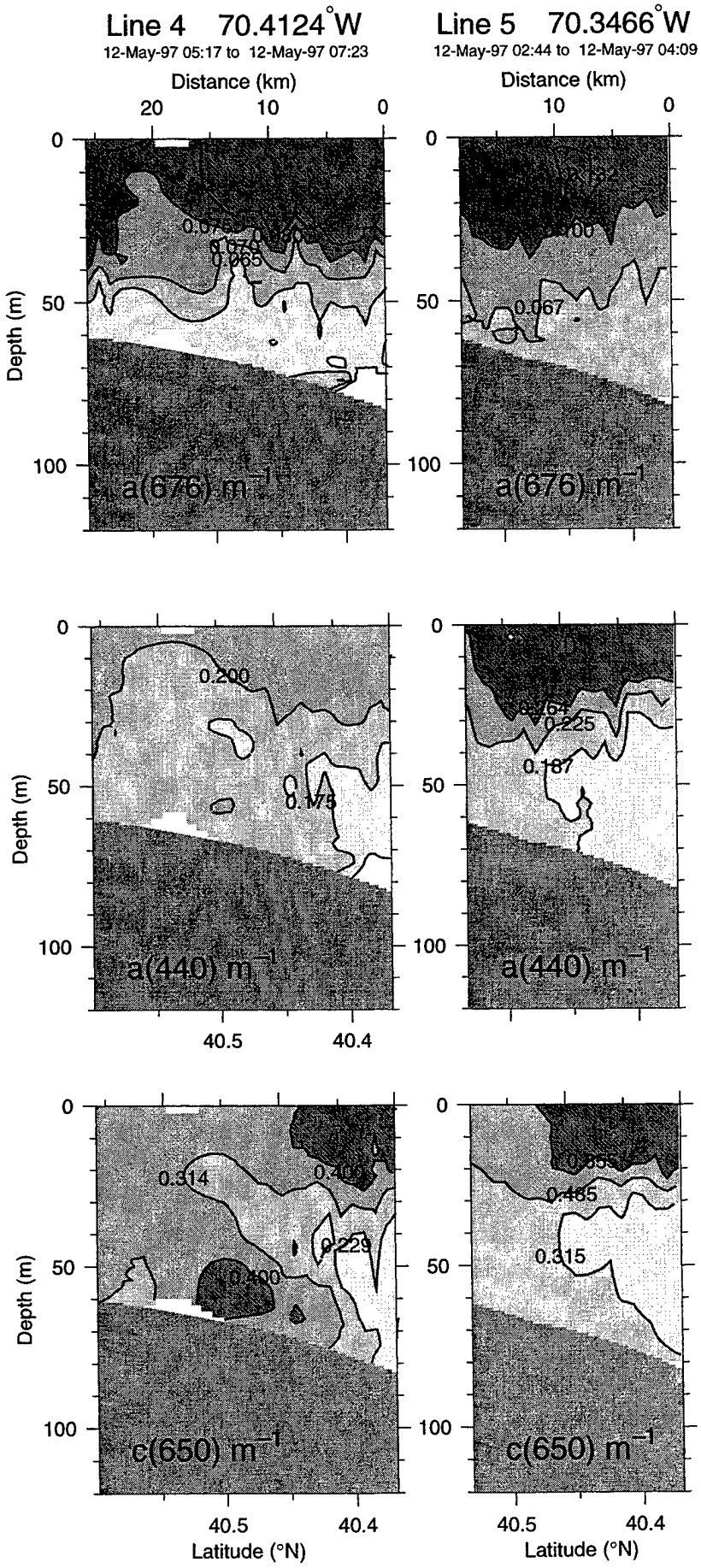
# E9704 Smallbox 8



# E9704 Smallbox 8



# E9704 Smallbox 12



# E9704 Smallbox 12